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ECONOMIC ANALYSIS OF PESTICIDE DISPOSAL METHODS

FINAL REPORT

March 1977

U.S. Environmental Protection Agency
Strategic Studies Unit
Washington, D.C. 20460

FINAL REPORT

ECONOMIC ANALYSIS OF PESTICIDE DISPOSAL METHODS

Contract No. 68-01-2614
Task No. 1

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by

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EPA REVIEW NOTICE

This EPA Report has been reviewed by the Office of Pesticide Programs and has been approved for publication. Agency approval does not signify that the contents necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

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I. SUMMARY

A. PURPOSE AND SCOPE

Under Section 19 of Public Law 92-516, the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA, amended), the Administrator of the Environmental Protection Agency is required to establish procedures and regulations for the disposal and storage of packages or containers of pesticides and for the disposal or storage of excess pesticides whose registration has been canceled. Within the past several years, recommended procedures for container and pesticide disposal have been published in the Federal Register and comments from the public have been received. The purpose of this study was to survey pesticide and container disposal practices in actual use and to develop information on their technical feasibility, cost, and potential environmental effects. More specifically, the study concentrated on determining the current methods and practices of pesticide and pesticide container disposal, the economics of these practices, and the types and quantities of pesticides and container disposal. Collection, transportation, treatment and ultimate disposal were examined along with attitudes of pesticide users concerning disposal methods. Reuse, recycle and deposit systems for pesticide containers were also considered. The potential environmental impact of disposal practices was studied.

The focus of this study was on the disposal of pesticides and containers used in the agricultural sector, with emphasis on pesticide containers. The information gained in the program was obtained from the literature and field studies in four representative states. The analysis of the costs of alternative disposal methods is made using data obtained from both literature and field studies.

B. RESULTS

1. Pesticide and Container Manufacture, Distribution and Use

The use of pesticides in the United States has increased from about 1 billion pounds per year in 1972 to about 1.4 billion pounds in 1976. Almost one-half of these amounts are herbicides, nearly forty percent are insecticides and the remainder are fungicides and other products. These pesticides are distributed through manufacturers, to formulators, to distributors, retailers, and finally consumers; the exact route varies considerably. For example, in the midwest, cooperatives are the principal distributors. In other locations, sales are often made directly from manufacturer to large consumers. In yet other locations, most sales are made through local cooperatives or retailers.

In 1971, crops accounted for almost 95% of all pesticides used by farmers. Sulfur was the most widely used fungicide product, primarily for citrus fruits, apples, vegetables, peanuts, potatoes and nuts. Almost

50% of all herbicides was used on corn, soybeans, and cotton. Important insecticides such as Toxaphene and methyl parathion, were used on corn, cotton, and other field crops. The use of pesticides in individual states has not been well documented; however, California is the largest user.

A study in 1970 estimated that 133,720,000 containers were used in the United States in 1966. A survey of farmers in 1971 showed that about 46% of all containers were liquid containers and 50% dry containers. Of the liquid containers, the majority were 1- or 5-gallons. Of the dry containers, the most prevalent were 4-5 pounds and 50 pounds and over. Container material was found to be about 46% paper, 35% metal, 11% plastic and 5% glass. Container use varies from state to state. For example, in Mississippi, 1-gallon plastic containers were the most widely used, while in California, Tennessee, and Utah paper containers were the most popular. In Montana, 5-gallon metal containers were the most common.

Disposal methods vary from state to state and by the type of container used. Generally, surveys show that paper containers are usually burned or buried. Metal or glass containers are either disposed with trash or washed out for future use. Contrary to other states where surveys were taken, Pennsylvania reported that 62% of the respondents to a survey disposed of containers in landfills. Unwanted or leftover pesticides are usually burned in bags by farmers and applicators. Other containers are buried or taken to landfills. In many cases, leftover pesticides are stored for later use. Dealers generally bury unused pesticides, take them to a landfill, or return them to the distributor.

EPA recommended procedures for pesticide and container disposal include incineration or disposal in landfills. Open burning, open dumping, water dumping, food and feed contamination, and well injection are generally prohibited. State regulations vary considerably but in states where there are regulations, they generally follow federal guidelines.

2. Field Studies

Field studies were conducted to develop more specific information on pesticide and container disposal methods, costs and usefulness of disposal methods in different areas of the country. The four states selected were Iowa, California, Mississippi and New York.

Iowa

The field visits in Iowa showed that burning on-site is the most prevalent practice for disposal of paper containers. Disposal of metal containers in landfills was a common and acceptable practice but thought wasteful of resources by many. However, rinsing of containers was common. Recycle or reuse would be acceptable if made simple and economical. Incineration was generally thought too expensive for general use. Other processes such as biodegradation, encapsulation, etc., were not considered practical or feasible in Iowa.

California

Regulations in California are very specific regarding the disposal of unused pesticides and the transportation, handling and storage of pesticide containers. County and state officials feel the disposal system is working quite well; however, field surveys showed some deviations.

Formulator/applicators generally triple rinse smaller containers and take them to a Class I (complete protection of ground water) or Class II-1 dump site (may overlie or be adjacent to usable ground water). Larger containers are recycled in some way or are reconditioned, usually with some type of deposit. In some cases, and with special permission, smaller containers are reused for the same material omitting triple-rinsing. Paper bags are usually disposed by burning in the field or disposed with other empty containers.

The disposal of empty containers and unused pesticides by small farmers may not conform to state regulations. Some containers are washed and then used around the farm, other containers and pesticides may be buried on the farm. Often containers are taken to local landfills (neither Class I or II).

Unused pesticides do not appear to be a great problem in California. County agricultural commissions sometime accept small amounts from users or transport them to a Class I dump. Applicators apply the pesticides as intended or take them to a Class I dump.

In general, regulations are followed, however, on examination of various records showed that many pesticide containers are disposed of through "non-approved" channels.

Mississippi

Bulk tank storage is becoming more popular in Mississippi and some companies rely almost totally on this type of distribution. However, the majority of pesticides are still sold in larger size containers (55-gallon drums).

The State Bureau of Environmental Protection has set up a program for solid waste disposal. Disposal containers are placed at various locations and solid waste, including pesticide containers, is collected. On the average, there is one container for every 150 people. These disposal containers are emptied periodically and taken to a sanitary landfill. For disposal, containers should be triple-rinsed, cans punctured, glass containers broken, and plastic containers slashed. These procedures, especially rinsing, are probably not often followed. Combustible materials can be disposed of in the solid waste containers, but they are more likely to be burned at the site of use.

Larger containers are beginning to be collected by the state for reconditioning. Otherwise, they may be collected by the cooperative or distributer and then sold to a drum reconditioner.

A study surveying disposal methods for pesticides in 1970 showed that about half were either buried or stored for future use. Another 25% were either applied to the soil surface or taken to the city dump.

New York

Little data are available on the container disposal problem in New York. It is thought by industry personnel that about 60-65% of pesticides sold in New York are marketed in paper bags or cartons. The remainder are sold in 1-gallon or 5-gallon plastic containers, and a few glass bottles.

The disposal of these containers is handled almost totally by burial. Farmers may also dispose of containers on a farm trash pile or at a local landfill. Commercial applicators usually operate on a small scale, and after the farmer is left to dispose of the containers. Larger containers are generally reconditioned.

Farmers having unused pesticides will usually store them for use the next year. One firm approved by the state uses incineration as the disposal method.

3. Analysis of the Cost of Container Disposal

The economic analysis showed that on-site disposal by burial, open dumping and burning are least costly to the pesticide user. The costs range from nil, to up to 50¢ per 5-gallon container. If containers are taken away from the farm for disposal, holding areas are usually economical. Calculations showed that if users transport containers, holding areas are economical if they are a few miles closer than disposal areas. If containers or pesticides are collected by a commercial organization, the incentive for holding areas is not so great. For example, holding areas located so the average user was 20 miles away would be economical only if the disposal site was more than 70 miles away.

The cost of most off-site disposal methods depends upon the scale of the operation and the distances required to transport containers. For any specific method, there will be a lowest or optimal cost which takes into account the rate of generation of containers and the average distance from the point of use to the point of disposal. The transportation and operating costs for encapsulation and burial range from as high as 25¢/lb for small facilities serving areas with low container generation density (i.e., 10 lb/sq mile/year), to as low as about 2¢/lb for larger facilities serving high generation rate areas (i.e., 200 lb/sq mile/year). Similar costs for incineration are, respectively, 28¢/lb and 2¢/lb, and for recycle by scrapping, 12¢/lb and 2¢/lb. However, for the latter two methods, costs can be partially offset by the sale of scrap. Disposal in sanitary landfills, each serving an area 70-150 miles in radius, was found to be optimal, costing 0.8 - 1.8¢/lb. Landfills serving a 50-mile radius with a low container density can be operated at 3.5¢/lb, much lower than other disposal systems for areas of low usage. Reconditioning larger drums was found to be economical if the reconditioning facility was less than about 450 miles from the holding area. In general, the cost of a returnable deposit system does not depend on the amount of the deposit. However, this deposit must be greater than the net cost to the user of returning the container to a holding area or disposal site.

4. Environmental Effects

Documentation of environmental and health effects of pesticide and container disposal has been poor in the past. Thus analysis can only be done from the viewpoint of potential effects.

Open dumping is likely to be the most hazardous method, posing threats to humans and wildlife through direct or indirect exposure. The hazards connected with controlled burial are somewhat reduced. Open burning of bags may also be dangerous, since temperature and oxygen supply are often inadequate for complete combustion and destruction of chemicals.

Environmental and health effects of holding areas can be minimized with proper controls. Sanitary landfills can pose few hazards if hydrogeologic conditions are suitable.

Encapsulation, unless a sealing material such as asphalt is used, would eventually result in the same effects as simple burial. Incineration offers the safest method of pesticides and containers, since degradation should be complete.

The disposal of unused pesticides by such methods as soil injection and biodegradation have limited application and require further investigation.

II. INTRODUCTION

A. BACKGROUND

During the past quarter century, intensive organic and inorganic pesticide development has resulted in the introduction of many new products and product forms into the agricultural chemical market and the increased use of those products. New types of insecticides, fungicides, herbicides, plant growth regulators, and combinations of chemicals are being manufactured, formulated, distributed, and used. Production of some pesticides is reaching new levels, while production of others is being severely limited because of substitution of new or improved products in the U.S. or foreign markets.

Concurrent with the increased use of pesticides, is the increased exposure to man and to the environment of pesticides, their residues, and related waste products. Concern for environmental quality and public health has led to legislative actions which may affect the research and development, production, use, and disposal of pesticides and their containers. More specifically, under Section 19 of Public Law 92-516, the Federal Insecticide, Fungicide and Rodenticide Act (referred to as FIFRA, amended or the Federal Environmental Pesticide Control Act of 1972--FEPCA), the administrator is required to establish procedures and regulations for the disposal and storage of packages and containers of pesticides and for the disposal or storage of excess amounts of such pesticides whose registration has been cancelled. Under Section 25 of this law, the administrator is authorized to establish standards with respect to the containers in which pesticides are enclosed in order to protect people from injury resulting from contact with those pesticides.

Pursuant to this authority, an initial document was published in the Federal Register on May 23, 1973, recommending procedures for the disposal and storage of pesticides, pesticide containers, and pesticide-related wastes. Following a public comment period, recommended procedures for the disposal and storage of pesticides were again published in the Federal Register on May 1, 1974; this republication reflected the concerns expressed by commentors representing both industry and the public. The recommended procedures, based upon investigation and study by the EPA and the Federal Working Group on Pesticides, apply only to the disposal of unused pesticides and pesticide containers by federal agencies and those products under federal control. On October 15, 1975 prohibited practices such as were outlined in the Federal Register.

Although the recommended procedures have been helpful, EPA regional staff and state environmental staff do not have sufficient information to recommend specific pesticide and container disposal practices, and may be unaware of the attitudes of pesticide users toward specific disposal methods. More information is required on current disposal practices, along with their technical feasibility, costs and environmental impacts to assist in preparation of specific recommendations to certified applicators and other pesticide users. This information will also be useful in environmental impact analysis of regulations concerning specific disposal actions.

B. PROGRAM OBJECTIVES

The overall objectives of this program are:

1. To determine the current methods and practices for disposing of pesticides and pesticide containers, the economics of these methods and practices, and the types and quantities of pesticides and containers disposed of by these practices.

2. To evaluate the economics of alternative methods for disposal of pesticide and pesticide containers, including the components of collection, transportation, and treatment or ultimate disposal.

3. To determine the attitudes of pesticide users concerning disposal methods and to evaluate the potential for cooperation with alternative approaches to pesticide and pesticide container disposal.

4. To examine alternatives to pesticide container disposal such as the reuse and recycle of containers, bulk transport of containers, and deposit systems using returnable containers.

5. To consider the environmental impact of current pesticide and container disposal practices and the potential environmental cost of alternative disposal methods.

Study Limitations

Because of the limited duration and effort of this program, the focus of the study has been on pesticides and pesticide containers used in the agricultural sector, rather than on institutional, home and garden, or other uses. Further, our effort was concentrated on disposal of containers with only secondary consideration given to the disposal of pesticides and other wastes. Attention was given to those disposal practices most commonly used or those which would most likely not be prohibited in subsequent regulatory actions, i.e., those practices with the least environmental hazards. The information gained in this program has been obtained through a sampling of states and persons involved in pesticide and pesticide container disposal and not through a complete national survey.

C. APPROACH

A brief review of the literature was undertaken to determine the available information on the state of the art of pesticide container disposal methods, on costs of disposal methods, and on the quantities of pesticides and containers which require disposal. The literature reviewed included scientific journals, agricultural and other trade journals, published federal reports and symposia, and other readily available literature. Computerized data bases such as NTIS, CHEMCON, and CAIN were searched. Pertinent articles were reviewed and abstracted.

Based upon the information contained in the literature, and contact with state environmental agencies, we selected several states for field studies. An initial field study was made in Iowa. Our staff contacted representatives of the state agricultural, environmental and health agencies, state universities, pesticide distributors, dealers, formulators, regional and local cooperatives, agricultural chemical associations, pesticide applicators, and farmers. Information was gained on current pesticide and container disposal practices, pesticide distribution systems, types and quantities of pesticides and numbers of containers used, current disposal methods, and attitudes of participants to alternative methods for pesticide and container disposal. Additional literature and information was obtained on the pesticide container disposal problem, on environmental hazards resulting from improper disposal, and costs of disposal methods.

Subsequent to this field study, we conducted similar field studies in California, New York, and Mississippi. Throughout these field visits we attempted to obtain information from participants in pesticide distribution, use and regulation, on the quantities and types of pesticide containers and pesticides for disposal, on the current disposal practices, the costs of current practices, the attitudes of various parties towards current disposal methods, and new approaches which are being tried. Instead of conducting a field survey in a fifth state, we contacted several state environmental agencies and others in the pesticide industry, to obtain a better overview of the differences in practices in different states, the current status of regulations, and current concern in the states for pesticide disposal.

Using the information obtained in these field studies, we conducted an analysis of the costs of several currently-used disposal methods considering both the effects and implications of transportation of pesticide containers and the scale of the disposal operation. We also examined a typical container deposit system, and the costs which may be incurred as a result of such a deposit system. The costs of disposal methods were analyzed through a generalized approach so that the relative costs of different methods could be compared on the basis of the distribution of containers and number of containers available for disposal.

This cost analysis, along with the results of our literature survey, field studies, and other contacts, are presented in this report.

D. REPORT ORGANIZATION

The following section of this report (Section III) presents general information we have obtained from literature, state agencies, and other sources. It includes a general discussion of pesticide manufacture, distribution and use patterns, pesticide and pesticide container disposal methods, and the status of state regulations related to pesticide and pesticide container disposal.

Section IV presents the results of our field studies in Iowa, California, Mississippi, and New York. An overview of the agriculture in each state and the pesticide distribution system is first presented followed by the status of regulations and state policies. Information on the number of containers used, disposal practices for both containers and pesticides, and the attitudes of participants in the disposal process are given. Available information on the costs of actual disposal operations is presented along with the brief description of the environmental effects of disposal noted in these states.

In Section V we present an economic analysis of principal disposal methods employed at the site of pesticide use and at a disposal site. Costs of transportation of containers and pesticides as well as a summary of system costs as a function of numbers and distribution of pesticide containers are discussed. Specific examples related to the states considered in the field visits are given. A brief analysis of a deposit system is also presented.

In Section VI we present a brief description of the environmental effects of current pesticide disposal methods. Section VII describes our conclusions and recommendations.

III. OVERVIEW OF PESTICIDE AND CONTAINER DISPOSAL

The production, distribution, and use of pesticides in the United States has been summarized in a recent EPA publication (von Rümker, et al., 1974). Although there is no single authoritative source of data on the quantities produced, imported, exported, and used throughout the various locations in the United States, the above mentioned report summarizes available information in 1974 and presents a relatively complete picture of the production, distribution, and use of 25 of the major pesticides. In this section we will summarize some of this information, and also discuss information obtained from the literature on numbers of pesticide containers distributed and used, on amounts of unused pesticides requiring disposal, and on regulations pertaining to pesticide and container disposal.

A. PESTICIDE MANUFACTURE

The production of insecticides, herbicides, and fungicides in the United States estimated from several sources is shown in Table 1. In the five-year period 1967 through 1971, the production of fungicides has remained essentially constant, whereas the production of herbicides and insecticides (including fumigants and rodenticides) has increased somewhat. The majority of the pesticides are synthetic organic pesticides. Data from another source--the U. S. Tariff Commission, 1972--indicate that approximately 451 million pounds of herbicides, 564 million pounds of insecticides, and 143 million pounds of fungicides were included as synthetic organic pesticides, making a total of 1,158 million pounds of active ingredients produced. Inorganic pesticides are approximately 10% of this total amount. In 1972, imports of pesticides were estimated at 23 million pounds and exports were estimated at 323 million pounds, leaving a domestic supply of approximately 976 million pounds of active pesticide ingredients.

B. PESTICIDE DISTRIBUTION

As shown in Figure 1, the manufacture and distribution of pesticides basically follows a pathway from manufacturers, to formulators, to distributors, retailers and finally consumers. There is considerable variety in the pathways and participants among states.

At the start of the distribution system are the manufacturers and formulators. The manufacturers generally are multi-product firms with pesticides comprising from 1% to 40% of their total business. Formulators tend to also be multi-product firms, although pesticides comprise a large percentage of their business. Both manufacturers and formulators vary from small to very large companies. Larger companies generally assume both roles, with facilities to convert their pesticide active ingredients into usable products. From the formulator, the product goes to the distributors who may be wholesalers, brokers, manufacturer branch offices or agents, and regional cooperatives. As with manufacturers and formulators,

Table 1. Representative Data on Pesticide Production

PESTICIDE TYPE	PRODUCTION (1000's lb AI) 1967	1971
Synthetic Organic and Inorganic[(1)]		
Insecticides	504,000	565,000
Herbicides	440,000	459,000
Fungicides	178,000	180,000
Total	1,122,000	1,204,000
Synthetic Organic[(2)]		
Insecticides	---	557,000
Herbicides	---	429,000
Fungicides	---	149,000

Sources: (1) U.S. Dept. of Agriculture (1973). The Pesticide Review, 1972, Agricultural Stabilization and Conservation Service, Washington, D.C.

(2) U.S. Tariff Commission (1973). U.S. Production and Sales of Pesticides and Related Products, Washington, D.C.

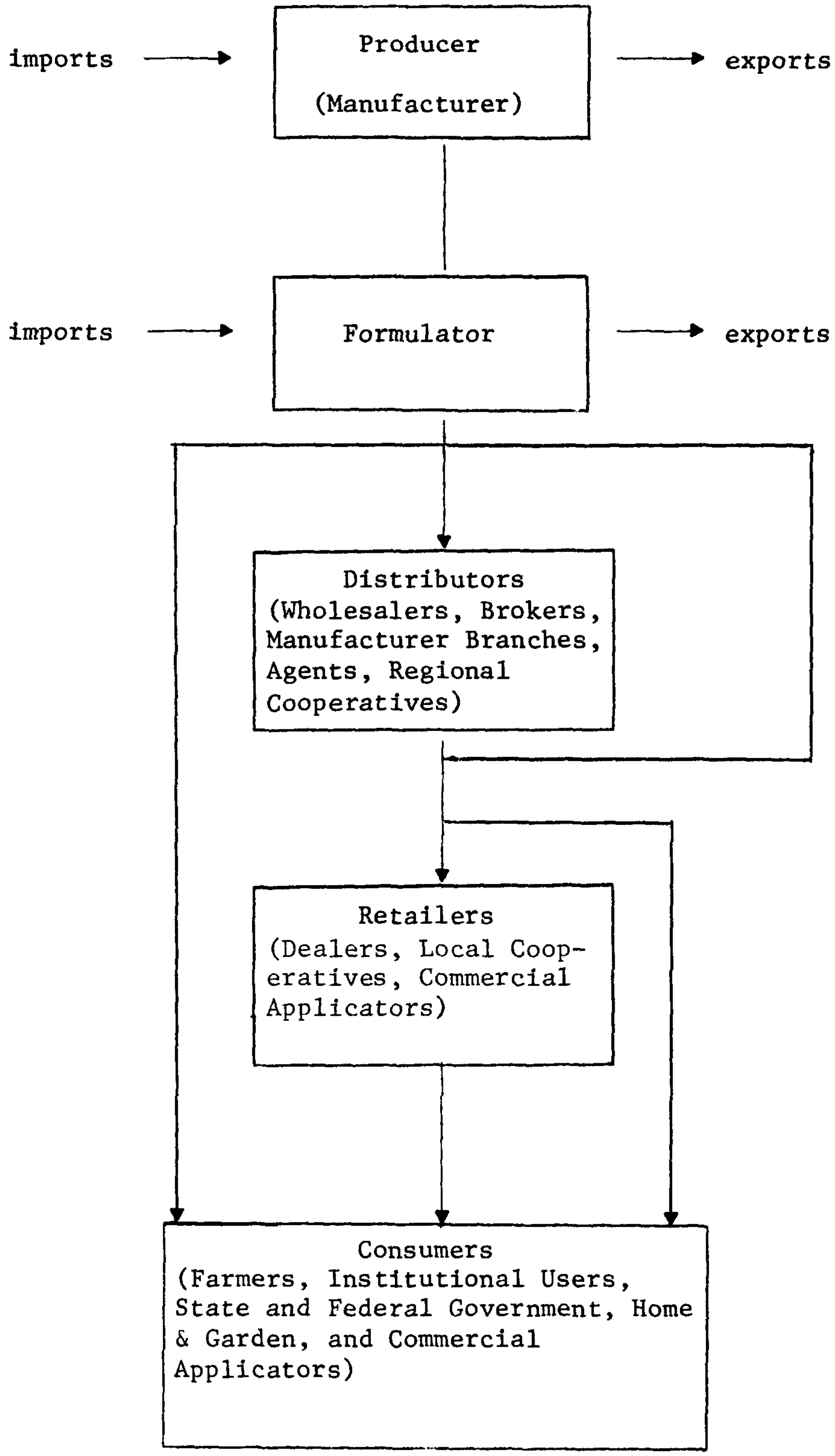


Figure 1. Channels of Pesticide Distribution

distributors vary considerably in size and may limit their operations in one sector of the state or extend over a large number of states. Distributors and regional co-ops generally handle several companies' products. In many cases, the formulator is also a distributor of pesticides.

The next distribution point is that of the dealer or retailer. A dealer may be a large wholesale outlet for pesticides or a small farm dealer. Local cooperatives and certain applicators are also dealers in the sense that they retail pesticides to other customers. Retail operations in pesticides may range from the "corner drugstore" which sells home and garden supplies to consumers, to a large dealer in a farm community that sells several million pounds of pesticides each year.

Consumers of pesticides are the final point in distribution. Consumers include farmers, institutional users, contract applicators (pest control operators), state and federal government agencies, and home and garden users.

The pesticide distribution practices in different areas of the country vary considerably. For example, in the midwest, regional and local cooperatives are often the principal centers for pesticide distribution. In California, on the other hand, regional and local cooperatives play only a small role in pesticide distribution. In many cases, sales are made direct from the manufacturer or manufacturer's branches to large consumers bypassing distributors and retailers. In other locations, practically all sales are made through local cooperatives or retailers direct to the individual consumer. A complex variety of distribution systems suggests that there are many persons and organizations involved with the handling and distribution of pesticides and their containers.

Because of this variability among states, no single method or approach to pesticide and container disposal which involves specific groups in the distribution chain will be acceptable across all states. Aspects of this variability as it affects viable disposal alternatives will be discussed throughout this report.

C. PESTICIDE USE

Statistics and data on the use of pesticides in the United States are generally difficult to obtain. The Department of Agriculture periodically prepares summaries of pesticides used, the major types, their distribution, principal crops requiring pesticides, etc. Unfortunately collection and analysis of data usually require from one to three years after the year for which the estimates of use were valid. For example, in July of 1974 the Department of Agriculture released a publication on the farmer's use of pesticides in 1971 (U.S. Dept. of Agriculture, 1974). The study was based on a survey of 8600 farmers throughout the United States. Data from the survey were expanded and adjusted to represent total crop and livestock production within the United States. Although the data will not be given in detail here, some figures are important because they show the nature of the chemicals used, the quantities, and the principal areas throughout the country in which the pesticides are used.

Crops accounted for almost 95% of all pesticides used by farmers in 1971. More specifically, crop use accounted for 95% of fungicides, practically all of the herbicides, 91% of insecticides and 85% of other pesticides used by farmers.

Sulfur was the most widely used fungicide product and accounted for more than three times as many pounds of all other fungicides used. Fungicides were primarily used on citrus fruits, apples, vegetables, peanuts, potatoes, and nuts. Approximately one-third of the fungicides used on farms were in the southeast, approximately 18% in the northeast, 17% in the Pacific, and 13% in the corn belt. Principal inorganic fungicides included copper sulfates, and other copper compounds. Principal organic fungicides included Maneb, Captan, Zineb, and others.

Atrazine was the principal herbicide used by farmers and accounted for nearly one-fourth of all herbicides used. Use of other herbicides was increasing considerably, including Amiben and Trifluralin. Herbicide 2,4 -D showed decreasing use. About 45% of all herbicides were used on corn, 15% on soybeans, 9% on cotton. Farmers in the corn belt accounted for about one-third of all farm herbicides used. The Lakes Region was second and the Northern Plains third, each accounting for about 12% of all farm herbicides used. Wheat and sorghum were other significant uses of herbicides.

About 90% of all insecticides used by farmers were applied to crops; most of these were organochlorine and organophosphorus compounds. In 1971, DDT and Toxaphene were the principal organochlorine insecticides. Their use has decreased significantly since 1971. Methyl parathion was the principal organophosphate insecticide at this time. Although its use has also decreased, other organophosphates have continued to be used in significant amounts. The use of carbamates has generally increased significantly. Over 47% of all insecticides used on farms were used on cotton, 17% on corn, and 11% on field crops such as wheat, sorghum, rice, peanuts, etc. Only about 7% was used on vegetables.

Although the compounds which are used most have changed sin 1971 as a result of the substitution of carbamates and phosphates for organochlorine insecticides, the general use of pesticides, in terms of their distribution throughout the country and the major crops for which they are used, remained about the same.

Use statistics for many states are not available. Less than half of the states require adequate records of pesticide sales and use. Table 2 indicates the diversity in pesticide usage among several states von Rümker, et al., 1974). These data were collected by a variety of methods from several states; probably the most reliable of the data comes from California where the usage for practically all pesticides is carefully recorded. (Available data on pesticide use in the states surveyed in this project are given later in the report under the appropriate section.)

Table 2. Typical Pesticide Use

STATE/COUNTY	YEAR	INSECTICIDES (Quantity 1000 lb AI)	FUNGICIDES	HERBICIDES	OTHER
Arizona	1972	9,353	144	838	
California	1972	28,622	2,965	16,091	
Illinois	1972	5,544	---	20,566	10,938[1]
Indiana	1970	2,688	---	7,298	
Michigan	1970	509	---	2,833	
Minnesota	1972	1,956	249	13,116	
Utah	1971	364	---	788	
Wisconsin	1970	574	---	5,124	
Canyon County, Idaho	1972	251	76	458	
Johnson County, Iowa	1973	22	14	98	
Washington, Bolivar and Sunflower County, Mississippi	1972	11,625 (17,827)[2]	1,385 (1,809)	3,343 (3,835)	

[1]Includes 28,000 petroleum hydrocarbons, 27,082 petroleum oil, 16,591 sulfur, 16,584 mercury-treated seed.

[2]Values are estimated by county agents--values in parenthesis are farmers' estimates.

Source: von Rümker, et al. (1974)

D. PESTICIDE CONTAINERS

Pesticides are distributed in a number of different types and sizes of containers. Heavy metal drums, in fifty-five, fifty, forty, thirty, and twenty-eight gallon sizes, are common for shipments of pesticides to large dealers, distributors and commercial applicators. Five-gallon metal containers seem to be one of the most popular sizes. They are purchased by distributors, dealers, applicators, and farmers. With the currently used rates of application of chemicals, the 5-gallon container may cover anywhere from 2 1/2 to 75 acres under normal conditions. It is a convenient size for the farmer to use; he can mix the chemical and not leave many containers partially filled. Smaller containers are primarily 2-gallon and 1-gallon containers of liquids, and occasionally even smaller containers primarily for the home and garden market. There are a large number of pesticides which are distributed in aerosol type cans. Granular or dry chemical pesticides are normally distributed in large bags of 50-pound size, usually paper or plastic impregnated. A large number of pesticides of wettable powder formulation are distributed in boxes, each of which contain a total of about 50 pounds divided individually into five or more small paper containers with from 5 to 10 pounds each. There is a current trend to move liquid pesticides by bulk shipment, i.e., large tanks containing pesticides from which dealers or distributors can refill containers specially designed for the purpose.

The most extensive information on the types of containers which are used and must be disposed of is the work of Fox and Delvo (1972) at the Dept. of Agriculture. Portions of their data are given in Table 3. These were collected from about 1500 farmers in 1971 whose responses were used to determine the size of containers used, container material and methods of disposal. As seen in the table, most liquid pesticides (82%) are purchased in 1-gallon or 5-gallon containers. Small containers, 1 quart or less, account for about 9% of liquid pesticides. The percentage of liquids in 29- to 55-gallon containers (about 8%) may be low because the sampling was primarily oriented to farmers rather than commercial applicators. Dry pesticides generally were purchased in 5-pound packages or 50-pound packages (85%) which is the way most dry pesticides are currently marketed. Of the total number of containers 71% are either paper or metal, with a relatively small amount (15%) of plastic and glass containers. There is some variation in the percentage of container materials among insecticides, herbicides and fungicides. Most of the insecticides (59.8%) are found in paper containers, while herbicides are split between metal (44%) and paper (42%) containers. Fungicides are almost entirely contained in paper (84%).

In addition to this national survey, there are several surveys in states and counties which describe the types of containers and numbers of containers which must be disposed of. Tables 4 to 8 present the information on numbers and types of containers from some of these states. (Additional information is given in Section IV under state site visits.)

Table 3. Sizes and Types of Containers Used by Farmers

Percentage distribution of farmer responses to pesticide container questions, United States, 1971

Item	Insecticides	Herbicides	Fungicides	All Pesticides
Size of Containers:				
Liquid containers				
1-pint or less	1.0	1.4	---	1.5
1-quart	3.9	2.6	1.0	3.3
1-gallon	14.0	18.5	5.1	19.7
5-gallons	10.1	24.5	2.0	18.4
29 to 30 gallons	0.7	3.6	2.0	2.8
50 to 55 gallons	1.6	.1	---	.8
Total liquid	31.3	50.7	10.1	46.5
Dry Containers:				
3 or less pounds	7.2	.9	13.3	3.3
4 to 5 pounds	19.1	30.2	30.6	24.8
20 to 25 pounds	9.0	2.6	4.1	4.4
50 pounds and over	27.8	13.9	25.5	17.6
Total dry	63.1	47.6	73.5	50.1
Other Containers	5.6	1.7	16.4	3.4
Total containers	100.0	100.0	100.0	100.0
Container Material:				
Glass	10.2	2.5	1.0	5.0
Metal	16.2	44.0	8.2	34.8
Paper	59.8	42.5	83.7	46.5
Plastic	10.1	8.4	5.1	10.9
Other	3.7	2.6	2.0	2.8
Total	100.0	100.0	100.0	100.0
Number of responses	666	1,373	98	2,357

Source: Fox and Delvo (1972).

Table 4. Estimates of Pesticide Containers in Mississippi - 1972*

55 gallon drums	61,902
30 gallon drums	8,342
5 gallon metal	169,498
5 gallon plastic	32,443
1 gallon plastic	995,217
1 gallon glass	25,558
1/2 gallon glass	3,525
1 quart or smaller	5,672
Total	1,302,157

*These numbers differ significantly from those reported in other years--see Section IV.

Source: University of Florida (1974)

Table 5. Estimates of Containers in California - 1970

55 gallon drums	8,000
30 gallon drums	98,000
small metal containers	346,000
paper containers	3,239,000
glass containers	91,000
plastic containers	81,000
Total	3,863,000

Source: Rogers and Cornelius (1970)

Table 6. Estimates of Containers in Montana - 1971

30-55 gal. drums	5,971
5 gal. metal	99,026
5 gal. plastic	30
1 gal. glass	80
1 gal. metal	2606
1/2 gal. glass	900
1/2 gal. metal	1655
30-50 lbs paper bags	5946
30-50 lb metal	3910
5 lb metal	2055
5 lb bags	541
200 lb fiber drums	328
20-25 lb fiber drums	4026
10-25 lb paper bags	15351
2-5 lb plastic	1300
Total	143,725

Source: University of Florida (1974)

Table 7. Estimates of Containers in Oregon - 1972

Containers for Liquid	
30-55 gallon drums	14,800
5 gallon or less (metal, glass, etc.)	998,000
Containers for Dry Materials	
>20 lb	215,000
<20 lb	975,000*

*includes pest strips, flea collars, etc.

Source: Univ. of Florida (1974)

Table 8. Types of Containers in Tennessee and Utah - 1970

	% of total	
	Tenn.	Utah
Metal drums	11%	3%
Metal cans	24%	31%
Paper bags	59%	56%
Glass containers	1%	6%
Plastic containers	5%	4%

Source: Tenn. Dept. of Agriculture (1970)
Univ. of Florida (1974)

Data from Mississippi, obtained through surveys of farmers located throughout the State, indicate that about 76% of the total containers are 1-gallon plastic containers and 13% are 5-gallon metal containers. Data from Montana, estimated by State personnel in 1971, indicate that about 69% of all containers are 5-gallon metal containers. In Oregon, data were obtained through surveys of major pesticide suppliers in 1972; because of the number of household containers included, percentages of types of agricultural containers cannot be determined. Data from Tennessee encompassed approximately 90% of pesticides used on the cultivated acreage in the State, showing the percentage of paper bags to be 59% and the percentage of metal cans to be 24%. Data from Utah represent pesticide applicators only. The percentage of paper bags from this survey is 56%, while the percentage of metal cans, 31%.

A report by Jansen (1970) estimates the total number of containers used for pesticides in the years 1964 and 1966 (Table 9). He derived these estimates through production figures reported by the U.S. Tariff Commission on Pesticide Review. He first selected 14 major pesticides as representative of the classes or groups to which they belong, whether these were averaged by type, i.e., liquid, dry or aerosol. He then estimated the quantity of active ingredient per gallon of formulation or per pound of formulation and the relative proportions of the representative pesticides packaged in different size containers. Combining this information with the production figures, he derived numbers of containers. He then estimated the number of containers used by farmers as opposed to other consumers, using the estimates of farm usage of pesticides.

As the above discussion indicates, most of the studies to estimate the numbers of containers in various states and counties are done on different bases. As a result, there is insufficient information for detailed comparison or for estimating the total numbers of containers based upon the type of agriculture and estimates of pesticide production and use.

E. METHODS OF DISPOSAL OF PESTICIDES AND CONTAINERS

Along with the surveys of numbers of containers and pesticides for disposal, several surveys have been conducted on the methods actually used for disposal of pesticides and containers. (Our discussion of site visits contains more detailed and up-to-date information.)

In 1972, the EPA conducted a pesticide study in five mid-western states--Illinois, Iowa, Kansas, Minnesota and Missouri. (von Rümker, 1972.) Methods of disposal in this five-state area, are shown in Table 10. The most prevalent method of disposal is burning of bags. In four of the states 10-35% of the containers were washed and reused as containers, presumably on the farm.

A study conducted by Tennessee Dept. of Agriculture (1970) also determined the methods used for pesticide container disposal. The results of this study reported in Table 11 indicate that apparently most of

Table 9. Estimates of Total Liquid and Dry Containers Used by U.S. Farmers

	Thousands of Containers	
	1964	1966
Liquid Containers		
55-gallon	574	605
5-gallon	5,646	6,193
1-gallon	11,865	12,773
Dry Containers		
50-pound	9,342	10,465
4-pound	92,600	97,543
Aerosol Containers	6,101	6,141
TOTAL	126,128	133,720

Source: Jansen (1970)

Table 10. Methods of Empty Pesticide Container Disposal in the 5-State Area of Illinois, Iowa, Kansas, Minnesota and Missouri

Methods Used	Illinois	Iowa	Kansas	Minnesota	Missouri
1. Throw in trash for pickup	14%	20%	22%	26%	17%
2. Burn	65%	70%	51%	85%	70%
3. Wash and store	40%	8%	9%	17%	15%
4. Wash and use as container	10%	3%	11%	17%	35%
5. Dump in ditch or field edge	8%	8%	13%	4%	9%
6. Bury	12%	5%	11%	9%	13%
7. Other	24%	21%	29%	9%	--

Source: von Rümker (1972).

Table 11. Pesticide Container Disposal in Tennessee Agriculture

Usage Per Survey	Metal Drums		Metal Cans		Glass-Plastics		Paper Bags		Combined Total	
	No. Used	% of Total	No. Used	% of Total	No. Used	% of Total	No. Used	% of Total	No. Used	% of Total
Recycled	5	4.4	23	0.9	85	4.2	29	0.2	142	1.7
Given Away	1	0.9	32	1.2	25	1.3	0	0.0	58	0.3
Used at Home	64	56.6	490	18.3	608	30.3	0	0.0	1162	5.5
Trash	43	38.1	1609	60.1	366	18.3	1314	8.0	3332	15.8
Burned	0	0.0	0	0.0	708	35.3	14,482	88.7	15,190	71.9
Buried	0	0.0	523	19.5	214	10.7	511	3.1	1248	5.9
Total Used	113		2677		2006		16,366		21,132	

Source: Tennessee Dept. of Agriculture (1970) the paper containers are burned, a large number of the metal and glass containers are thrown in the trash and a sizable number of containers, mostly metal drums and glass, are washed and used in the farm or at home.

The results of a pesticide usage study conducted in Adams County, Penn. (Pennsylvania Dept. of Health, 1971) in 1970, indicate that approximately 62% of those responding to the survey disposed of containers in landfills, 16% burned on the premise, and another 16% buried on the premise. The remainder of the responses indicated disposal in municipal incinerators, other dumps, etc. This survey did not study the number of containers which were disposed of by these methods. The study also determined that less than 10% of those responding rinsed out their pesticide containers, whereas approximately 25% rinsed equipment. The wastewater was disposed of on the ground in practically all cases.

A study conducted by the Institute of Agricultural Medicine in an Iowa community (Iowa Community Pesticide Survey, 1972) indicated that of the farmers having leftover pesticides, 63% store them for further use, 22% return them to the dealer, 9% bury them on the farm, 6% discard them on unused land, and the remainder discard them in sanitary landfills. The survey also found that some 42% of the respondents indicated they would be willing to return unwanted pesticides and empty containers to a local dealer and pay a fee for safe disposal. About 82% would be willing to pay up to $5 per year; 15%, $10 per year; and 2% would be willing to pay more than $20 per year.

In another Iowa study, the Farm Bureau in 1970 surveyed their members to determine container disposal methods. (Ryan, 1974) Some 72% of those responding to the survey burned empty pesticide containers, 12% returned them to pesticide dealers, 34% indicated they either burned them or took them to the dump. Thirty-four percent of those responding had leftover pesticides. Forty-four percent of those responding would be willing to pay a fee to have their pesticide containers disposed of safely. Fifty-six percent indicated they would pay $5 per year; 40%, $10 per year; and 4%, $20 per year.

The results of the study by Fox and Delvo (1970) showing the methods of disposal are given in Table 12. Most pesticide containers are burned, almost 20% are disposed of in a private dump, 11% are retained for unknown purposes, and the remainder are disposed of by a variety of means. Although only 11% of the respondents indicated that the containers were returned to the dealer or delivered to a commercial dump, 52% of the respondents indicate that they would dispose or bring containers to a collection point.

Surveys of applicators in Oregon indicate that 87% of containers are disposed of in landfills or are buried on the applicator's property. (University of Florida, 1974.) Nine percent of the containers are left with the applicator's clients for disposal and the balance are reused.

Table 12. Method of Disposal of Containers Used by Farmers

Percentage distribution of farmer responses to pesticide container questions on container disposal, and collection preferences, United States, 1971.

Item	Insecticides	Herbicides	Fungicides	All Pesticides
		Percent		
Method of Disposal:				
Returned to dealer	1.9	3.1	4.1	3.1
Burned	61.0	45.0	71.4	49.2
Buried	3.7	6.6	7.1	5.8
Private dump	16.7	18.4	2.0	18.9
Commercial dump	7.1	9.6	8.2	8.4
Left in field	1.3	.7	--	.9
Left where sprayer filled	.6	1.5	--	1.1
Retained	6.9	13.3	4.1	11.0
Other	.8	1.8	3.1	1.6
TOTAL	100.0	100.0	100.0	100.0
Would use collection points:				
Yes	52.3	51.3	46.9	51.6
No	47.7	48.7	53.1	48.4
TOTAL	100.0	100.0	100.0	100.0
		Number		
Number of responses	666	1373	98	2357

Source: Fox and Delvo (1972)

The recent study of pesticide disposal practices in Iowa done by Ryan (1974) provided information on the methods of disposal of pesticides leftover in the application equipment, methods of disposal of empty pesticide containers, and of unwanted pesticides. The results of this survey for pesticide applicators, and farmers, are shown in Table 13. The results indicate that both farmers and applicators burn most containers (presumably bags) on the property, and either bury or take to landfills or dump the remainder of their containers. Most applicators and farmers apply pesticides which are leftover as originally intended, or else store them for future use. Dealers generally bury unwanted pesticides, take them to landfills, or return them to distributors. Some pesticides are stored or given to others for use. Applicators follow essentially the same practices, with some being returned to dealers. Only 28% of the farmers, 32% of the applicators, and 58% of the pesticide dealers, indicated they had excess waste pesticides. As discussed in later sections, some of the reports of individual farmers and applicators in our Iowa field study differ from results of Ryan's mail survey.

It is not surprising that there is little published information on the quantities and types of pesticides which require disposal. Unless a specific survey has been conducted by state and agricultural departments or other organizations, this information is generally lacking. Most pesticides which require disposal are those which are outdated, have been removed from the market or are prohibited from use, those which do not meet specifications for the product, and those which have been sold or given to dealers and retailers who no longer can find the retail market for these pesticides. In general, farmers who have pesticides available will use them rather than dispose of them and see "money wasted." Dealers also may give some pesticides away to farmers rather than be responsible for disposal. Practically all dealers have several barrels or containers of pesticides which they can no longer sell and must find a means of disposal. Most farm personnel, we believe, store, from year to year, those unused pesticides which can be effectively used on their own property. DDT and others which are no longer usable, however, may be located on the farm and need to be disposed. In general, most of the pesticides requiring disposal will occur at dealers, distributors and major farm operations, as well as industrial locations.

The EPA study conducted in 1973 summarized some quantities of pesticides stored at various locations (Environmental Protection Agency, 1973). For example, in Alaska some 300 containers ranging in size from 5-gallon to 55-gallon drums containing pesticides were considered excess and needed disposal. In addition, a considerable amount of DDT and copper-chromium-arsenic compounds were ready for disposal. In Florida, a collection and disposal program resulted in some 93,000 pounds of mixed pesticides being stored in 1970 awaiting disposal. A similar program in Georgia for picking up pesticides resulted in considerable amount of DDT and other mixtures ready for disposal. Considerable amounts of DDT and

Table 13. Disposal Practices in Iowa From Survey of Dealers, Applicators and Farmers

	Percent of Respondents Using Indicated Disposal Methods						
	Containers		Leftover Pesticides in Equipment		Unwanted Pesticides		
	Applicators	Farmers	Applicators	Farmers	Dealer	Applicator	Farmer
Burn on property	44	84	2	7	18	7	27
Bury on property	13	24	9	6	39	44	27
Take to landfill	57	26	7	5	39	33	32
Take to dump	24	18	2	2	18	0	15
Burn in incinerator	0	1	-	-	-	-	-
Leave in field	5	2	-	-	-	-	-
Put in ditch or ravine	0	6	0	1	2	-	2
Return to dealer	5	7	-	-	31	41	20
Use for storing pesticides	1	3	-	-	-	-	-
Use for storing other substances	7	2	-	-	-	-	-
Throw in trash	6	3	0	0	2	0	2
Take to cooperage or recycle	3	0	-	-	-	-	-
Store	5	1	17	17	26	11	24
Leave in equipment for next job	-	-	20	5	-	-	-
Give to someone else who needs it	-	-	5	10	28	19	10
Spray or apply as intended	-	-	60	61	33	19	39
Never have leftover	-	-	44	49	-	-	-
Pour on ground	-	-	7	10	10	-	12
Pour in drain	-	-	3	0	0	0	2
Special disposal system	-	-	6	1	7	0	0
Other	0	0	0	3	2	0	0

Source: Ryan (1974)

dieldrin are also ready for disposal in Kentucky. Other states such as Maine, Massachusetts, Michigan, have a considerable amount of DDT and other pesticides stored for disposal. The State of Montana has collected a large number of different types and quantities of pesticides for disposal and store the material in an ammunition bunker. Over 20,000 pounds of pesticides are stored pending disposal in that state. In New Hampshire about 5 tons of pesticides are being stored in the State and there are an estimated 1 million pounds of pesticides to be disposed of in New York. The State of Washington also has considerable quantities of pesticides for disposal.

Data such as these are quite sporadic and are not considered to be very up to date. Periodically, some in-depth surveys are conducted by state and federal agencies to determine quantities of pesticides awaiting disposal. Surveys of farmers taken by mail or telephone frequently indicate that there are excess pesticides stored and ready for disposal, although some people are not willing to admit to the fact that they have material which might be outdated, adulterated, or not suitable for application.

F. STATUS OF REGULATIONS ON PESTICIDE AND CONTAINER DISPOSAL

1. Federal Regulations

As mentioned in the introduction, recommended procedures for the disposal and storage of pesticides and pesticide containers were published in the Federal Register, Vol. 39, No. 85--May 1, 1974. The recommended procedures for the disposal of pesticides and pesticide containers given in these rules and regulations apply to all pesticides which may be registered for general or restricted use or covered under an experimental use permit, with certain exceptions including pesticides for home and garden use. The disposal procedures are to be used by the Environmental Protection Agency in carrying out its pesticides and pesticide container operations. These procedures are recommended for all others who wish to dispose of pesticides or pesticide containers.

Several procedures were not recommended. These include disposal or storage of pesticides, pesticide containers and container residues in a manner inconsistent with the pesticide label, or applicable state or federal pollution control standards. Open dumping was prohibited (FR Vol. 39, No. 200) and open burning was prohibited only for small quantities when allowed by state and local regulations. Water dumping or ocean dumping was also not prohibited except in conformance with appropriate regulations.

Disposal of Pesticides

Recommended procedures for disposal of organic pesticides include incineration and, if incineration facilities are not available, burial in specially designated landfills. Soil injection, chemical degradation, and well injection were not recommended unless specific guidance is obtained from appropriate authorities and cautions taken to avoid environmental effects. Metallo-organic pesticides should be disposed of by incineration or burial in specially designated landfills. Disposal of these materials by soil injection, chemical degradation, and well injection again are not recommended without specific guidance and adequate demonstration that safety and environmental quality are maintained. Organic mercury, lead, cadmium, arsenic, and inorganic pesticides are to be disposed of by chemical deactivation or conversion to non-hazardous compounds. If chemical deactivation facilities are not available, these pesticides should be temporarily stored or encapsulated and buried in specially designed landfills. In addition, no pesticide or pesticide-related waste shall be disposed of or stored near or in such a way as to contaminate food, feed, or feed packing materials.

Disposal of Pesticide Containers

The following is an excerpt from the recommended procedures published in the Federal Register, Vol. 39, No. 85.

> (a) Group I Containers. Combustible containers which formerly contained organic or metallo-organic pesticides, should be disposed of in a pesticide incinerator, or buried in a specially designated landfill, except that small quantities of such containers may be burned in open fields by the user of the pesticide when such open burning is permitted by State and local regulations, or buried singly by the user in open fields with due regard for protection of surface and sub-surface water.
>
> (b) Group II Containers. Non-combustible containers which formerly contained organic or metallo-organic pesticides, should first be triple-rinsed. Containers in good condition may then be returned to the pesticide manufacturer or formulator or drum reconditioner for reuse. Other rinsed metal containers should be punctured to facilitate drainage prior to transport to a facility for recycle as scrap metal or for disposal. All rinsed containers may be crushed and disposed of by burial in a sanitary landfill, in conformance with State and local standards or buried in the field by the user of the pesticide. Unrinsed containers should be disposed of in a specially designated landfill, or subjected to incineration in a pesticide incinerator.
>
> (c) Group III Containers. Containers (both combustible and noncombustible) which formerly contained organic mercury, lead, cadmium, or arsenic or inorganic pesticides and which have been triple-rinsed and punctured to facilitate drainage, may be disposed of in a sanitary landfill. Such containers which are not rinsed should be encapsulated and buried in a specially designated landfill.

Residues and rinsed liquids should be disposed of through use in spraying operation in the field or otherwise disposed of in accordance with the methods described above for individual pesticides.

2. State Regulations

State regulations vary from being "non-existent" with respect to pesticides and pesticide containers, to very specific and complex regulations and procedures for disposal of pesticides and pesticide containers. A recent study (University of Florida 1974) summarized current state laws. In about 15 states, there are no specific laws applicable to pesticide and pesticide container disposal. In other states legislation was being formulated at the time this report was prepared. In several states, environmental regulations prohibit the disposal of pesticides or containers in such a way as to cause injury to persons, wildlife, or the environment but no specific recommendations for disposal are given. Specific regulations and laws pertaining to pesticide and pesticide container disposal exist in a few agricultural states which have been leaders in environmental regulation. Some examples of status of state regulations in March 1975 are given below. Details of regulations in the states visited in our field survey will be given in Section IV.

North Dakota

The regulations for pesticide use and disposal are to be ready for enactment by July 1, 1975. The anticipated regulations will be similar to current EPA regulations. The regulations are being developed by the newly formed Pesticide Division of the State Department of Agriculture.

North Carolina

Draft regulations for pesticide and pesticide container disposal were prepared in August of 1974. In accordance with the North Carolina Pesticide Law of 1971, the North Carolina Pesticide Board is authorized to establish regulations concerning the disposal of pesticides and pesticide containers. The proposed recommended disposal methods for pesticides parallel those of federal regulations. With respect to containers, the state recommends that combustible containers normally containing organic or most metallo-organic pesticides be disposed of in a pesticide incinerator or buried in an approved landfill. Non-combustible containers of less than 30 gallons which contained organic or most metallo-organic pesticides should be triple rinsed, drained and transported to a disposal facility--an approved sanitary landfill. Unrinsed containers should be disposed of in a specially designated landfill or incinerated. Containers of less than 30-gallon capacity which contained organic mercury, lead, cadmium, arsenic, or inorganic pesticides, should be triple rinsed and disposed of in an approved sanitary landfill; non-rinsed containers should be disposed of in a specially designated landfill. Containers larger than 30-gallon capacity may be disposed of, after triple rinsing, in approved landfills through September 1, 1975. Another part of the proposed regulations will require that all manufacturers and dealers offering pesticides for sale in containers of more than 30-gallon capacity shall be required to impose a container return deposit of at least $5 but not more than $25 upon each purchaser. The required deposit will be returned to the purchaser upon return of the container to the seller, provided the containers returned have been triple rinsed and all bungs, lids or openings closed. North Carolina also has regulations pertaining to the use and storage of pesticides in bulk containers; however, they do not contain specific regulations on the disposal of these bulk containers.

Oklahoma

The State of Oklahoma has proposed draft regulations for container disposal which parallel in practically all respects the federally recommended disposal procedures. In addition, the State has issued requirements for sanitary landfills and specially designated landfills for the disposal of certain pesticide containers.

Pennsylvania

The State of Pennsylvania has recommended that small containers such as aerosol cans and empty bags be brought to a landfill after sealing them and placing them in newspaper or other wrapping to prevent leakage. Flammable containers may be burned provided local burning ordinances or pollution regulations are not violated. Burning containers of herbicides, or aerosol containers, is not recommended. Large non-flammable containers should be returned to manufacturers. If this cannot be done, the containers should be triple rinsed and brought to a landfill or disposed of on the user's land if suitable conditions exist. Containers should be punctured and crushed, if possible. Considerations for determining the suitability of the site for land disposal of containers are given in the recommendations. These include: distance from streams, water supplies, or livestock feeding areas, types of soils, and depth of disposal pits. It is also recommended that unused pesticides be returned to manufacturers or their representative or be used by other farmers, pest control firms or agencies. Where this is not possible, incineration is recommended. Commercial firms are to be contracted if large quantities of waste materials exist.

Georgia

The Dept. of Agriculture is charged with the administration of the Georgia Pesticides Use and Applications Act. The only current law existing is that containers should be disposed of in a manner that does not endanger human life or the environment. When state laws are promulgated, they will follow federal laws.

New York

New York state laws require that unused pesticides be incinerated or buried at specially designated sites. Containers may be buried in specially designated sites on the farm or returned to the formulator. When new laws are promulgated, they will conform to federal statutes.

California

California has stringent regulations with regard to pesticide and pesticide container disposal. A series of landfill sites of several classes specifically designated for disposal of pesticides, other hazardous wastes, and pesticide containers has been established. Criteria for these landfills have been established. Pesticide disposal and pesticide container disposal operations are under the jurisdiction of the Dept. of Agriculture, appropriate state environmental protection agencies, and county agricultural commissioners. A description of the current regulations is given in Section IV.

Alabama

The State of Alabama regulations and guidelines recommend using normal solid waste disposal channels for disposal of pesticides and for container disposal. Where these are not available, a program of specially developed landfills will be established. Large numbers of containers or large concentrations of unused pesticides should be disposed of at Class A landfills which are specially selected after due consideration of soil type, water table, surface flow, etc. Smaller quantities of pesticides and pesticide containers generated by farm operators, applicators, etc., which do not justify transportation to centralized Class A sites may be disposed of in Class B landfills which are designated areas within existing sanitary landfills. Class C landfills are sites for pesticide disposal and container disposal which are located on the property of farmers, industrial organizations, etc., who choose to dispose of their own pesticide containers. Recommendations for these types of landfills are also proposed.

In general pesticide and pesticide container disposal regulations are often proposed by the pesticide control boards and promulgated by the state environmental, health, or agricultural agencies. It is expected that most state regulations will follow the already published federal regulations.

IV. FIELD STUDIES

A. INTRODUCTION

Field studies were conducted to develop information on:

1. Currently used pesticide and container disposal methods, including reuse or recycle of containers;

2. Costs of currently-used disposal methods, including labor, handling, transport, facilities, equipment, etc.;

3. Availability of disposal sites and/or equipment;

4. Relative usefulness of various disposal methods;

5. Attitudes of pesticide dealers and users toward disposal methods including reuse, recycle and returnable deposit systems.

A number of criteria were used to select states for field studies: value of agricultural production, types of farms, pesticide use, major crops, degree of urbanization, status of pesticide and container legislation and regulations, and geographic location. For example, it was desirable to select states which differed in their amounts of agricultural production because of the expected difference in degree of pesticide usage, and levels of pesticide and container regulations. It was desirable to select states which were urbanized as well as rural agricultural, and to select ones from several geographical regions because of different major crops, different pest problems, and perhaps different attitudes toward pesticide and container disposal.

States initially considered for field studies included: California, Texas, Iowa, Minnesota, Nebraska, Colorado, Virginia, New York, Montana, Illinois, Indiana, Kansas, North Dakota, Alabama, Georgia, North Carolina, Wisconsin, Florida and Washington. Based upon a brief literature review, telephone contacts with agricultural and environmental staff in these states, and review of the criteria mentioned above, we selected Iowa, California, Mississippi and New York for the field studies. A fifth state was to be selected, if necessary, based upon the results of the initial four studies. It was subsequently concluded that it would be more effective to continue and expand telephone contacts with several states to assess the types of environmental and health problems encountered with pesticide and container disposal and to identify any new techniques or information on disposal, rather than conduct a fifth in-depth field study.

Prior to each field study and where readily available, we developed background information on each state including: agricultural production, pesticide usage, major pesticide distributors, formulators, and dealers, cognizant agricultural and environmental agencies, and other potential companies and disposal contractors. A series of questions or discussion topics for major participants in the field studies--state agencies, dealers, farmers, etc.--was prepared.

In each field study we attempted to meet with: regulatory and administrative agencies--state and local agricultural and environmental agency staff, university extension services staff; companies or persons involved in pesticide distribution and sale--pesticide formulators, distributors, dealers; pesticide users--ground and aerial applicators, farmers; persons involved with pesticide and container disposal--disposal contractors, cooperage firms, drum reconditioners, landfill operators; and other interested parties--agricultural chemical associations, equipment manufacturers, etc.

All persons contacted were very cooperative in providing available information and expressing their attitudes on pesticide and container disposal. We were somewhat disappointed at the apparent lack of hard data on pesticide and container usage, numbers of containers disposed of by alternative methods, costs of actual disposal operations, and documented evidence of health or environmental damage caused by improper pesticide or container disposal.

B. IOWA FIELD STUDY

1. Overview of Agriculture in Iowa

Iowa's economy is dominated by agriculture and industry related to agriculture. Approximately 18% of Iowa's total labor force (about 210,000 persons) is employed on the farm. Another 16% of the labor force is employed by enterprises directly related to agriculture, while another 46% of the labor force hold jobs that are indirectly related to farming. Thus, 80% of Iowa's total employment is directly or indirectly related to agriculture. Approximately 95% of Iowa's total land area is devoted to farmland; the production of crops accounts for about 55% of total land use in the state. Thus, from the perspective of employment, land use, and personal income, agriculture is very significant in the economy of Iowa.

The agriculture of Iowa revolves around the feeding of hogs and cattle. Iowa ranks number 1 in the nation as a producer of hogs, and number 2 or 3 as a producer of cattle. During 1971-1973, Iowa accounted for approximately 22.5% of the U.S. hog production and approximately 7% of the U.S. cattle production. Iowa also ranks number 1 as the nation's producer of corn and number 2 as the nation's producer of soybeans. Table 14 shows the major crops grown in Iowa, the 1971-1973 average number of acres harvested for each crop, total production, and total farm value.

Table 14. Acreage Harvested, Total Production and Farm Value of Iowa's Major Crops, 1971-73 Average

Crop	Acreage Harvested	Production	Farm Value
	1,000 acres	1,000 units	1,000 dollars
Corn (for grain)	11,100	1,203,933 bu.	1,823,413
Soybeans	6,467	221,117 bu.	998,163
Hay (all varieties)	2,377	6,996 tons	167,672
Oats	1,375	75,433 bu.	60,472
Corn (for silage)	605	9,171 tons	N. A.
Grain Sorghum	52	4,353 bu.	4,923
Winter Wheat	32	1,154 bu.	2,098
Sorghum (for silage)	17	234 tons	N. A.
Irish Potatoes	3.0	598 cwt.	1,691
Apples	N.A.	11,400 lbs	1,225
Sweet Corn	9.2	8,950 cwt.	983
Pop Corn	39.0	126,517 lbs.	N. A.

N. A. Not Available

Source: U.S. Department of Agriculture

During this period Iowa accounted for 18% of U.S. corn acreage and 21% of U.S. corn production; 13% of U.S. soybean acreage and 16% of U.S. soybean production; and 4% of U.S. hay acreage and 5% of U.S. hay production. Much of Iowa's corn and soybean production is fed to Iowa's hogs and cattle.

2. Pesticide Use in Iowa

The state of Iowa does not require pesticide distributors or farmers to report on the quantities of pesticides sold or used each year. However, von Rümker (1972) has estimated on a regional basis the quantities of major chemical pesticides used on corn, soybeans, and small grains in the five state area of Illinois, Iowa, Kansas, Minnesota, and Missouri for the 1971 growing season. Her estimates for the five state region appear in Table 15. In 1971, Iowa accounted for 36% of the corn acreage and 28% of the soybean acreage in those five states. Assuming that the pesticide usage patterns are roughly the same in these five states for the major crops of corn and soybeans, Iowa farmers applied approximately 20.5 million pounds of herbicides on corn, 6.9 million pounds of herbicides on soybeans, and 8.3 million pounds of insecticides on corn during 1971.

Ryan conducted a survey of farmers, pesticide dealers, commercial applicators, and householders in Iowa to determine the attitudes of pesticide users and handlers. As a part of this survey he asked farmers what basic type of pesticides they used during 1972. Of the 1974 farmers responding, 153 (87.9%) indicated thev used pesticides in 1972. Table 16 indicates the types of pesticides used as the percentage of responding farmers who used these pesticides.

Wallace's Farmer (WF) is an Iowa farm publication which periodically conducts a random survey of its subscribers to determine the use of agricultural chemicals and fertilizers among its readership. A questionnaire was mailed by WF in 1972 to which 696 farmers responded.

According to the returned questionnaires, 87% of all the respondents used some kind of herbicide during 1972. Table 17 indicates the principal weeds for which the herbicides were applied and the percentage of farmers who used herbicides.

Of all the respondents who raised corn, approximately 86% used a herbicide on their corn crop. Eighty-eight (88%) percent applied the herbicide only once, while 10% applied a herbicide twice. Table 18 indicates the herbicides most commonly used on corn and the type of formulation applied.

Of the respondents who raised soybeans, 81% of them used a herbicide on this crop. Ninety-six (96%) percent of these treated only one time while the remainder treated twice. Table 19 indicates the herbicides most commonly used on soybeans and the type of formulation applied.

Table 15. Estimated Quantities of Herbicides and Insecticides Used in the Five-State Area of Illinois, Iowa, Kansas, Minnesota and Missouri on Corn, Soybeans, and Small Grains in 1971

	Chemical Name	Crop	1000 lb of Active Ingredient
Herbicides	Atrazine	corn	30,000
	Propachlor	corn	18,700
	Amiben	soybeans	13,600
	Alachlor	soybeans	7,100
	Alachlor	corn	4,350
	2,4-D Type	corn	3,825
	2,4-D Type	small grains	3,200
	Trifluralin	soybeans	3,970
		Total	84,745
Insecticides	Adlrin	corn	11,000
	Bux	corn	2,800
	Heptachlor	corn	2,660
	Phorate	corn	2,364
	Toxaphene	corn	2,000
	Carbaryl	corn	1,200
	Diazinon	corn	662
	DDT	corn	200
	Parathion	corn	80
		Total	22,966
		Grand Total	107,711

Source: von Rümker, 1972.

Table 16. Percentage of Iowa Farmers Responding to Survey Questionnaire Who Applied Various Types of Pesticides

Type of Pesticide	Percentage of Use
Herbicides	87
Crop Insecticides	63
Seed Pesticides	19
Stored grain insecticides	1
Livestock or poultry insecticides (applied on animals)	54
Food additive insecticides	16
Fly control insecticides (not applied on animals)	54
Crop fungicides	1
Rodenticides	28
Other pesticides	1

Source: Ryan, 1974

Table 17. Principal Weeds for Which Chemical Herbicides Were Applied - Iowa

Weed	Percent*
Foxtail	54.2
Thistle	36.2
Smartweed	29.6
Butterprint (Buttonweed)	26.7
Cocklebur	20.0
Pigweed	9.0
Sunflower	8.6
Quackgrass	8.1
Broadleaf weeds	7.5

*Percentages are based on the respondents who used herbicides on their farm.

Source: Wallace's Farmer Agricultural Chemical and Fertilizer Survey, 1972.

Table 18. Principal Herbicides and Formulations Used on Corn - Iowa

Principal Herbicides

	Percent*
AAtrex	49.6
2,4-D	28.6
Ramrod	25.2
Lasso	19.2
Banvel	6.7
Sutan	6.5
Atrazine/Lorox	4.7
Bladex	4.7
Ramrod/Atrazine	3.3

Formulations

Liquid	58.4
Wettable powder	44.0
Granular	29.0

*Percentages are based on the respondents who used herbicides on their farm/

Source: Wallace's Farmer Agricultural Chemical and Fertilizer Survey, 1972.

Table 19. Principal Herbicides and Formulations Used on Soybeans - Iowa

Principal Herbicides	Percent*
Amiben	43.8
Treflan	40.0
Lasso	21.0
C.I.P.C.	4.3
Preforan	2.7
Lorox	2.5
Formulations	
Liquid	60.2
Granular	39.8
Wettable powder	4.3

Table 20. Principal Types of Soil Insects Treated and Principal Chemicals Used for Control of Soil Inseets

Soil Insects	Percent**
Rootworms	84.9
Cut worms	34.5
Wire worms	26.3
Maggots and beetles	11.2
Root lice	8.2
Grubs	7.7
Principal Chemicals	
Aldrin	34.9
Bux	31.5
Thimet	28.8
Furadan	14.7
Heptachlor	8.3
Dyfonate	6.9
Diazinon	4.0
Aldrex	2.7
Dasanit	2.4

*Percentages are based on respondents who raised corn.

**Percentages are based on respondents who treated for soil insects.

Source: _Wallace's Farmer_ Agricultural Chemical and Fertilizer Survey, 1972

Of the farmers who raised corn, 57% of them indicated that they used a soil insecticide on their corn crop. The most common target insects are shown in Table 20. Of these farmers, 99% applied a soil insecticide once, while the other 1% applied it twice. Table 20 also shows the chemicals commonly used as a soil insecticide for corn.

3. Pesticide Distribution System

The pesticide distributon system in Iowa can be described as having five levels as shown in Figure 2. The arrows indicate the typical flow of chemicals. There are several exceptions to the flow indicated in the figure. Local co-ops occasionally purchase from an independent distibutor; similarly an independent dealer may purchase from a regional co-op. Chemicals will sometimes be transported from a producer directly to a local co-op with the regional co-op serving as an ordering house and transportation coordinator.

Some firms perform more than one function in the system. For example, some local co-ops in Iowa also serve as commercial applicators for their farmers. Some independent dealers are also commercial applicators. Farmers often serve as applicators for their farmer neighbors. Several private firms both wholesale and retail pesticides.

Table 21 indicates the estimated number of firms in the pesticide distribution system in Iowa. These estimates are based on a synthesis of conversations with government and industry personnel in the State, and are intended only to indicate the rough number of participants in the distribution channels.

4. Magnitude of the Pesticide and Container Disposal Problem

In addition to determining the attitudes toward pesticide container disposal on the part of farmers, dealers, commercial applicators and householders, Ryan (1974) also attempted to ascertain the magnitude of the disposal problem. Based on responses from 174 farmers, 87 applicators and 204 householders, Ryan estimated the number of pesticide containers that required disposal in 1972 as shown in Table 22.

Ryan's questionnaire also asked pesticide users if they had any empty containers on hand at the time for disposal. Table 23 indicates the percentage of each group of respondents who said they did have empty containers requiring disposal along with an estimate of the number of such containers held in the State. Unfortunately, Ryan did not estimate the number of pesticide containers by type, i.e., paper bags, 5-gallon metal cans, glass or plastic containers, or 30 or 55 metal drums.

Table 24 shows the typical types of containers for the more common pesticides used in Iowa. Discussions with industry personnel indicate that approximately 50-60% of pesticides used in Iowa are marketed in paper bags or cartons. The remainder are sold in 1-gallon or 5-gallon metal cans, with few 30-gallon or 55-gallon metal drums, 1-gallon

Figure 2. Pesticide Distribution System in Iowa

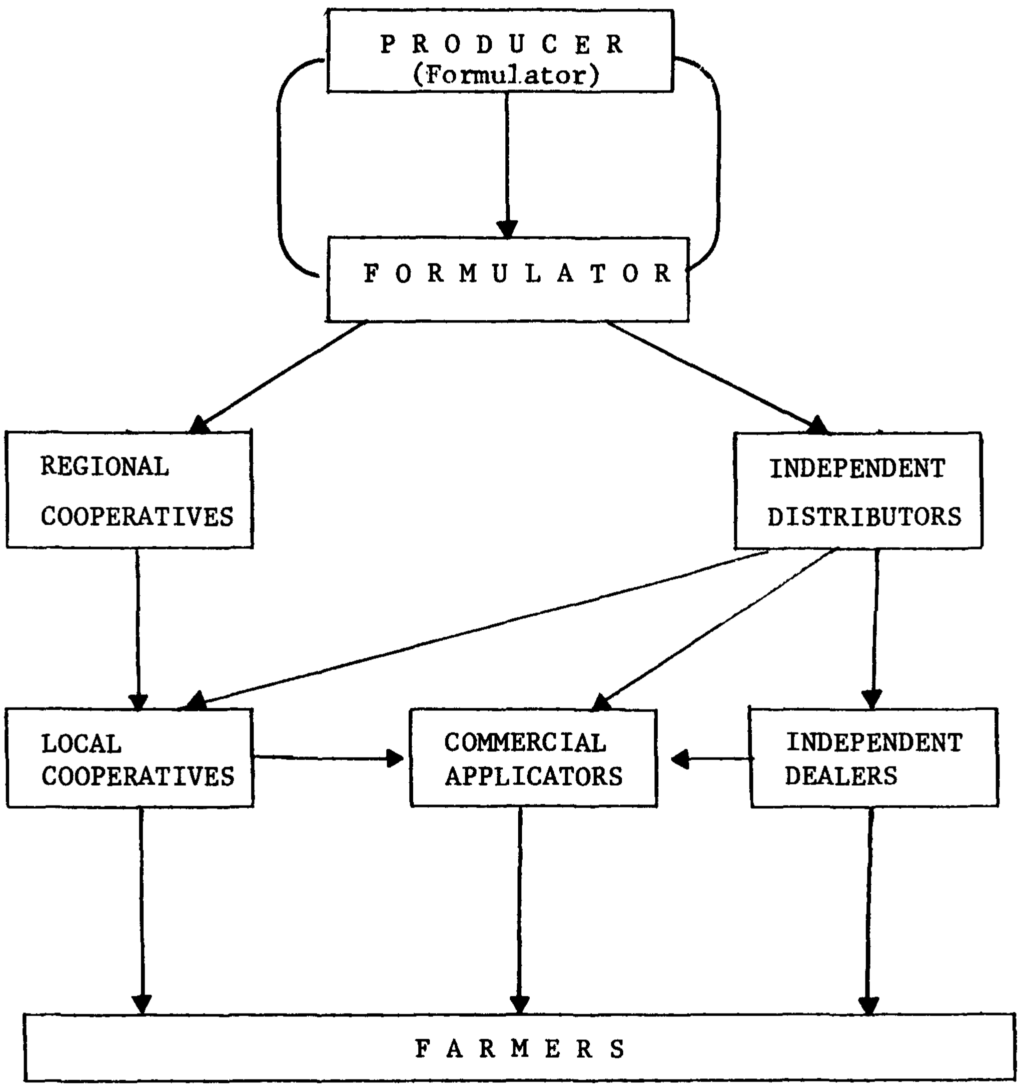


Table 21. Type and Estimated Number of Firms in the Pesticide Distribution System in Iowa

Type of Firm	Number
Formulator	2
Regional Cooperatives	3
Independent Distributors	25-50
Local Co-ops	550-600
Independent Dealers	>500
Aerial Applicators	50-100
Ground Applicators	800-900
Farmers	137,000

Source: Arthur D. Little, Inc. estimates based upon discussions with state and industry groups.

Table 22. Estimated Number of Empty Pesticide Containers Disposed of in Iowa During 1972

User	No. of Containers
Farmer	3,050,000
Commercial applicator	480,000
Householder	1,940,000

Source: Ryan, 1974

Table 23. Percentage of Questionnaire Respondents in Iowa Who Possessed Containers Requiring Disposal, and the Estimated Number of Such Containers in Iowa in 1972

User	Percentage of Respondents Having Empty Containers (%)	Estimated Number of Empty Containers in Iowa
Farmer	7.5	94,000
Commercial Applicator	14.0	11,300
Pesticide Dealer	17.1	48,100
Householder	3.5	18,600
Total		172,000

Source: Ryan, 1974

Table 24. Typical Containers for Pesticides Commonly Used in Iowa

Name of Pesticide	Type of Container
AAtrex	paper bags and metal cans
2,4-D	paper bags and metal cans
Ramrod	paper bags
Lasso	paper bags and metal cans
Amiben	paper bags
Treflan	metal cans
Aldrin	paper bags and metal cans
Bux	paper bags and metal cans
Thimet	paper bags
Furadan	paper bags

Source: Personal communication, Mr. Everret Leach, Land O'Lakes, Inc., Fort Dodge, Iowa or 5-gallon plastic containers, and glass bottles. Thus, of the three million containers disposed of by farmers, almost two million are paper bags or cartons, and perhaps 700,000-800,000 are metal containers, if Ryan's estimates are correct.

As discussed earlier, a typical Iowa farmer grows primarily corn and soybeans and feeds cattle and hogs. A typical farm would be about 250 acres with 120 acres devoted to corn production and 70 acres devoted to soybean production. Some of the remaining land would be used to produce alfalfa or small grains and a small portion would be used for farm buildings.

Normally one application of a herbicide, such as AAtrex, would be applied to the corn acreage after planting but before plant emergence. The farmer might use 90 small paper bags of AAtrex. The empty bags would typically be burned in the field at application time. Usually one application of a herbicide, such as Amiben, would be applied to the soybean crop--between planting and preemergence. From this application the farmer may have about fifteen 5-gallon cans requiring disposal. From the application of a soil insecticide on the corn acreage, the typical farmer might be left with ten 5-gallon empty containers or he might apply in granular form which uses paper bags.

Pesticide control on the smaller crops and fly control in the cattle operation would typically result in several more empty containers. Thus the typical farmer might end up with twenty to thirty 5-gallon containers to be disposed of each year and perhaps 100 empty bags of other chemicals. These estimates would give a somewhat higher total than Ryan's estimates.

Ryan also investigated the magnitude of the problem of unwanted, illegal, or obsolete pesticides. Table 25 indicates the percentage of respondents who currently had unwanted pesticides, and an estimate of the statewide quantities of unwanted pesticide in 1972.

5. Status of Regulations and State Policies on Pesticide Disposal

In 1975, the State of Iowa had no regulations or policies specifically pertaining to the disposal of pesticides and pesticide containers. It is illegal to burn pesticide containers (bags, and cardboard boxes) but a farmer may dispose of them on his own property, provided he does not endanger the public health and welfare.

The Deparmtent of Environmental Quality, Solid Waste Division, was preparing legislation for the 1975 state legislature. These laws will follow EPA guidelines concerning pesticide and container disposal.

As of July 1, 1975 all open dumps will be closed. Only approved sanitary landfills will be allowed to accept pesticide containers. However, there are no approved sites for sanitary landfills at present nor have criteria for approving these sites been established.

Table 25. The Percentage of Questionnaire Respondents in Iowa Who Sometimes Have and Who Currently Had Quantities of Unwanted Pesticides and State-wide Estimate of Unwanted Pesticide Quantities in 1972

User	Percent of Respondents Who Sometimes Have Unwanted Pesticide	Percentage of Respondents Who Currently Had Unwanted Pesticides	Estimated Quantity of State-wide Unwanted Pesticides	
	(%)	(%)	(lb)	(gal)
Farmer	28	4	129,100	12,400
Commercial Applicator	32	8	157,700	1,200
Pesticide Dealer	58	11	35,200	500
Householder	16	2	11,200	900
Total			333,200	15,000

Source: Ryan, 1974

6. Current Disposal Practices

The methods for pesticide and container disposal currently practiced in Iowa are very loosely structured. This is due in part to the lack of specific regulations and part due to the relatively low significance given to the disposal problem. In general, the comments we obtained on the disposal of specific types of containers were substantially the same from most of those people interviewed. Views of various persons directly connected with or interested in this disposal problem are given below.

The Chemical Technology Commission of the Land Division of the Department of Environmental Quality (DEQ) is responsible for the development of the laws and programs pertaining to pesticide and container disposal. Although there is currently no official policy regarding container disposal, as of July 1, 1975, all open dumps in the State will be closed and any remaining landfills will have to be managed. The requirements of a "properly managed dump," if enforced, will make it more difficult for most people to dispose of containers.

The State environmental and agricultural staff feel that some pesticide containers are taken to landfills, but that a farmer who has only a few containers probably buries (or burns) them on this property. State staff believe that burial on private property does not generally create a hazard to public health and may be more desirable than concentrating the materials at one location, such as a landfill. The containers that eventually reach a landfill are not likely to have been rinsed or punctured. Farmers most often burn their pesticide bags along with their seed and fertilizer bags. Although it is illegal to burn pesticide bags or cardboard cartons in the field, the DEQ recognizes that most farmers burn them anyway and the regulation is not enforced. State staff believed that most distributors did not "want to be bothered" with the disposal problem and that chemical companies are becoming increasingly interested in bulk deliveries to distributors and dealers.

With regard to unused pesticides, the view of the State staff is that the problem and its solution is mainly with the dealer. The reasons for quantities of unwanted pesticides remaining on hand were:

1. A chemical being banned or suspended;
2. A chemical becoming unpopular with farmers;
3. A carton, bag, or can of pesticide becoming adulterated;
4. Containers beginning to leak;
5. Stockpiling for various reasons; or
6. A sudden increase in an insect's resistance to a particular pesticide.

While they felt that the farmers usually have small quantities of unused pesticides which they usually apply as directed, they were unsure as to what dealers did with unwanted pesticides. The consensus was that the manufacturer and/or the distributors/dealers should assume some responsibility for disposal of unused pesticides.

The Iowa Fertilizer and Chemical Association is concerned with the container disposal problem. They have printed and distributed about 35,000 brochures which outline their recommended procedures--triple rinsing the 5-gallon can and draining it before puncturing and disposing of it by burial. They believe that farmers are better at following these guidelines than are commercial applicators, because applicators are often working under great time pressure and do not have the time to triple rinse during their application process.

The association staff felt that most landfill operators in the State do not want agricultural chemical containers to be disposed of in these sites. Thus, they believe that most farmers simply throw their empty containers in the ditch or pile them in a grove somewhere, rather than dispose of them in a more satisfactory manner.

They believe that producers and formulators do not wish to refill empty or reconditioned containers because of the cross-contamination problem. There are, however, two drum reconditioners in the State--Des Moines Barrel and Drum Co., and Scott Drum Co.

The Des Moines Barrel and Drum Co. no longer desires to recondition pesticide drums since two of their employees became very sick several years ago after cleaning out some pesticide drums without taking the proper precautions. They are willing to accept drums of "non-toxic" pesticides, mostly herbicides. Drum reconditioning is not widespread, however.

Several individuals at Iowa State University have been interested in the pesticide and container disposal problem. Ryan's study (using a mailed questionnaire) asked the question, "How do you most frequently dispose of your empty pesticide containers?" The results are summarized in Table 26 for farmers and commercial applicators. The general range of responses to these questions is about the same as we obtained through the limited sample of farmers and dealers we contacted in person in this study. Most farmers bury or burn containers; few take them to landfills or dumps. Most applicators burn paper containers and bring metal or plastic ones to landfills or dumps. The methods most frequently used for disposal of unwanted pesticides, found by Ryan, are shown in Table 27.

Ryan's major conclusions concerning the disposal problem is that "unwanted pesticides and containers are being primarily disposed of in ways that can be considered unsafe." Ryan believes that the farmer is the principal problem in the disposal situation and the one who is least committed to safe and correct disposal. He also feels that too many individuals are involved in the distribution and use of pesticides and recommends stricter licensing procedures.

Table 26. Disposal Methods for Container

METHOD	% RESPONDENTS USING METHODS COMMERCIAL APPLICATOR	FARMER
Burn on private property	44.2	83.6
Bury on private property	12.8	24.0
Take to landfill	57.0	26.0
Take to dump	24.4	17.8
Burn in city incinerator	0	0.7
Leave in field where used	4.6	2.1
Put in ditch or ravine	0	6.2
Return to dealer	4.7	6.7
Use for storing pesticides	1.2	2.7
Use for storing other substances	7.0	2.1
Throw in trash pickup	5.8	2.7
Take to cooperage or reconditioning firm	3.4	1.4
Store	4.7	1.4

Source: Ryan, 1974

Table 27. Disposal of Unwanted Pesticides

METHOD	% OF RESPONDENTS USING METHOD COMMERCIAL APPLICATORS	DEALER	FARMERS
Pour on ground	0	9.8	12.2
Pour over area designed for hazardous waste	0	6.6	0
Apply as intended	18.5	32.8	39.0
Bury	44.4	39.3	26.8
Burn	7.4	18.0	26.8
Take to landfill	33.3	39.3	31.7
Take to dump	0	18.0	14.6
Place in ditch or ravine	0	1.6	2.4
Return to dealer or distributor	40.7	31.1	19.5
Throw in trash pickup	0	1.6	2.4
Give to someone who needs it	18.5	27.9	9.8
Store	11.1	26.2	24.4
Other	0	1.6	0

Note: One farmer reported pouring the pesticide down the drain to a septic system.

Source: Ryan, 1974

Other individuals at the University have dealt with the disposal of pesticides. At one time extension service staff sent all of their material to the Dow Company incinerator in Midland, Michigan. Dow will no longer accept unused pesticides, however. Following this, they sent about 100 barrels of unused pesticides to an AEC disposal site in Illinois. This site is no longer accepting material either. Now a sizable quantity of pesticide is stored in an old bunker within the State and the University staff continue to store material rather than dispose of it in any way. The feasibility of disposing of pesticides in an incinerator is being studied. Plans are to "update" an existing incinerator and conduct a test program.

We interviewed two of the three major regional co-ops which operate in Iowa. The staff at one co-op believe that most farmers triple rinse and drain the cans and then either throw the containers away in the field or bring them to a landfill or dump, if one is close to their farm. Bags are generally burned in the field or at the mixing site.

With regard to commercial applicators, this co-op staff believe that the operators have less of a problem than the farmers. The commercial applicators usually have a fenced-off area to store containers and most of the empty containers are disposed of in a landfill. They feel that commercial applicators either burn bags in the field or bring them back to the applicator's property to be burned.

The co-op's policy is that damaged bags can be returned but they try to avoid accepting any partial containers or damaged bags. They will usually give a price break to the local co-op and ask them to dispose of it or give it to a good customer.

The people at another regional co-op had a slightly different impression of the disposal practices. They believe that paper bags and cartons are generally burned in the field immediately after use and very few farmers bother to bury these containers. The 5-gallon metal containers are typically thrown in the farm dump, stored in a shed or just deserted along the edge of the field. In a few cases, they said farmers might try to take them to a local dump, but this is probably a very small portion of farmers in the State. Plastic containers, they believe, are burned in the field or deserted the way metal containers are deserted. Larger containers (drums), which commercial applicators have, are likely sold to a reconditioner or to various other people for unspecified uses.

The co-op staff felt that the major disposal problems fall into two basic categories:

1. Pesticide containers--mainly a farmer's problem; commercial applicators probably can "afford" to go to a landfill because of the large numbers they have; and

2. Unwanted pesticides--resides with the pesticide dealer; they do not know how to handle this problem.

The local co-ops who are distributors, and sometimes commercial applicators, are closer to the user than are the regional co-ops and have a different perspective on the disposal problem.

One local co-op which operates a commercial application service, said that the employees bring cans back to the co-op and when a large number is collected, the containers are taken to a dump. At the dump, the containers are run over by a tractor and buried. This is said to be atypical of most dumps in Iowa. Sometimes applicators bury the cans on the farmer's property, if the owner gives permission. The other alternative is to dig a pit on the applicator's own property and dump the cans in it after crushing them with a tractor. Bags are generally burned in the field. Triple rinsing is not done because it is too time-consuming.

Another local co-op commercial applicator generally rinses the cans and lets them drain. He then takes them to a nearby sanitation service (for dumping). Bags are burned in the field or brought back to the co-op.

Another local co-op occasionally has unwanted pesticides which they either sell at a reduced price or price or may ask a farmer to spread on field free of charge. The containers from their commercial application service are disposed of in a nearby municipal sanitary landfill, which covers and packs every day. Bags and cartons are burned in the field.

Independent dealers, many of whom operate commercial application services, gave us their views of the farmers' practices and their own. One independent dealer was unsure how many containers actually are rinsed but he does feel that most containers are taken to a landfill. Bags are burned in the field.

Three other independent dealers we interviewed (who are also commercial applicators) indicated that they do not rinse cans because of the time factor. All brought their containers to a landfill. Two of them also brought paper bags, the other dealer burns the bags in the field. They believe that very few farmers rinse the cans. Most farmers, they thought, burn bags and dump cans in the field or on the farm trash pile. One of the dealer-applicators indicated that farmers may also use the cans for other purposes on the farm.

Dealers' comments on the fate of unwanted pesticides included:

- Pouring on ground,
- Applying in recommended manner,
- Burning, and
- Landfilling.

One aerial applicator interviewed indicated that he may rinse some of the containers at the end of the day and use the rinse water for making up the next day's batch of pesticides. He brings his containers to the county dump. Bags are usually burned in an old 55-gallon drum on the airport property.

With respect to existing disposal facilities, there is no suitable incinerator for pesticides in Iowa. There are two drum reconditioners who accept a small number of containers for reconditioning. There are no approved landfills for pesticide disposal; a large number of local dumps have been used for disposal of containers and pesticides. There is one storage area used by State University staff for unwanted or excess pesticides; this is not suitable for increased use by others in the State.

7. Cost of Disposal Practices

Information on the cost of disposal in Iowa was limited due to the lack of structured, formal disposal operations. The economic data that were obtained in interviews is summarized below.

- Typical dealer/applicator pays "about $4 per truckload" to dispose of unrinsed, uncrushed containers in the local dump.

- A disposal company in a nearby state will incinerate containers based on the type of material which the container held. For 30- to 50-gallon drums, the charges per container are:

  $13.00-$20.00--halogenated liquids
  $ 8.50-$15.00--flammable materials
  $11.00-$18.00--semi-solid materials
  $18.00-$25.00--solidified material

  All prices are based on a concentration of 20% or less. An increased concentration will increase the disposal cost.

- At one cooperative there is a deposit system in effect for oil drums. The charges are: 15-gallon - $5.00; 30-gallon - $8.00; 55-gallon - $10.00.

- A reconditioned drum sells for about $5.50, but the purchase price for drums to be reconditioned could not be determined.

8. Attitudes Toward and Acceptance of Disposal Methods

In our discussions with distributors, dealers, applicators and others contacted in this study, we inquired about the methods they thought were most feasible and desirable, those they thought were not useful, and their general attitude and acceptance of various methods of container and pesticide disposal. Following is a discussion of general attitudes and acceptance of disposal methods and comments of those we interviewed on specific methods.

a. General Attitudes and Acceptance

There are considerable differences in the general attitudes of distributors and users regarding disposal of pesticides and containers. For example, the study by Ryan (1974) indicated that a number of farmers, applicators, and dealers would be willing to pay for pesticide and container disposal. In Ryan's survey, 75% of the applicators, 85% of the pesticide dealers, and 71% of farmers indicated that there was a need for a disposal system in Iowa for unwanted pesticides and pesticide containers. Sixty-one percent of the applicators, 82% of the dealers, and 48% of the farmers indicated they would be willing to pay a fee for disposal of empty pesticide containers and unwanted pesticides. Applicators were generally willing to pay $20-50 or more per year; pesticide dealers were also willing to pay similar amounts. No farmer, on the other hand, felt it would be worth paying more than $10 per year for a disposal service. Sixty percent of the applicators, 50% of the dealers, and 68% of the farmers indicated that any disposal fees should be included in the pesticide purchase price. Eighty-nine percent of the applicators, 90% of the dealers, and 82% of the farmers indicated they would be willing to deliver pesticides and containers to a safe disposal site at their own expense. Applicators generally were willing to travel up to 50 miles for disposal; pesticide dealers were willing to travel 50 or more miles, but farmers generally were not willing to travel more than 25 miles for safe disposal.

We obtained a mixed reaction from distributors and dealers on their role in the disposal process. For example, one dealer believed that most dealers, applicators and distributors would cooperate and participate in any organized disposal practices. He felt that the weakest link would be to get the small farmer to return pesticide containers to a place where they could be properly handled. Another pesticide dealer indicated that he would like to operate a service whereby farmers could return empty containers when they want full ones or when they buy present time because he has no place to store pesticide containers and no easy way to dispose of them. He believed that if he offered the service, farmers would of their own accord bring the cans because farmers are concerned with the hazards involved and the appearance of their farms.

One regional cooperative indicated that 4 or 5 of the cooperatives have encouraged farmers to bring containers back to the local co-op for disposal. This was done primarily for "good will" to encourage the farmer to buy the co-op products. It was felt that if a sufficient number of acceptable sites could be established for disposal, more local co-ops would be willing to participate in such a disposal system.

On the other hand, several distributors and dealers felt that they do not want to get into the disposal business and that someone else should specialize in it. Some felt that the most practical solution was to have a state agency or disposal system contractor operate disposal sites and a collection system. The basic point made by some was to reduce the number of transfers of empty containers from farmers to dealers to co-ops to disposal site and to make the disposal process as direct as possible. This was felt to be particularly important in a state such as Iowa where containers are well distributed throughout the State and the logistics of the disposal system are important.

One dealer/applicator indicated that a 25-50 mile trip for disposal of containers would be acceptable to him since he has several hundred containers to dispose of each spring. However, he felt that the farmer would not return containers to him nor would he like to accumulate the cans or dispose of them.

A different viewpoint was expressed by a commercial applicator who indicated the manufacturers should bear some of the costs of the disposal of containers.

In general, most people interviewed were concerned about the disposal of containers and were seeking a solution. A potential solution offered by regional co-ops was to have a larger percentage of pesticides delivered in bulk. They expected that the amount of pesticides applied by commercial applicators will increase, and as a result, there would be a greater need and opportunity to have more chemicals delivered in bulk tanks. This would eliminate part of the need for disposing of empty containers, however it would not affect the disposal problems of the smaller farmers and those who do not use commercial applicators.

A suggestion proposed for 5-gallon metal containers was to make the container of even thinner stock than now used so that there would be little likelihood for farmers, or anyone else to reuse the container for other purposes after the pesticides had been applied. This alternative does not seem very practical since many dealers and distributors already claim problems with leaking cans and cans damaged in transit.

With regard to pesticide disposal, most people felt that, except for pesticides that were no longer registered, there was little problem with unused or unwanted pesticides. Most believed that the best way to handle excess pesticides was to have farmers use them as they originally intended. Several people felt that as a result of pesticide shortages and the increase in costs of pesticides there were far fewer excess pesticides left on the farm, and as a result, there are fewer problems of pesticide disposal.

b. On the Farm Disposal

Several regional cooperatives believe that the farmer now has an acceptable, safe and economical way to dispose of containers on or close to his farm. The best way was to burn bags and to put containers in a "safe" location on the farm or bring to a local dump. A common concept of "safe" location on the farm is not accepted by many; to the farmer it may mean the trash pile or a back lot; to others it may be an approved, fenced location away from surface water; still others would require the equivalent of an approved sanitary landfill.

c. Burning

The general attitude of all persons interviewed was that burning of bags and cartons was an adequate and acceptable method of disposal for paper containers. The only precautions stressed were: not too many should be burned at one time; people should stay out of the smoke; and plastic coated bags might be rinsed and brought to landfills. Several people objected to bringing bags to landfills because they blew all over and were a hazard.

d. Rinsing of Containers

Although the triple rinse program has been emphasized by dealers, the extension service, trade associations and state agricultural staff, there is some question of its acceptance. As mentioned in earlier sections, commercial applicators often do not "have the time" to rinse containers.

Staff at the extension service have attempted to get farmers to rinse containers by emphasizing the economics of the situation, i.e., indicating that there are 5 or 6 ounces of good pesticide left in the container which, if properly rinsed, can be used. They believe, as do several pesticide dealers, that redesign of containers would be very useful so that little active ingredients will remain in the container and that triple rinsing may not be necessary.

Several regional and local cooperatives believe that less than 5% of the farmers triple rinse containers at the present time. As a result, there could be toxic hazards in local dumps or county disposal sites.

e. Landfills

In general, state environmental and agricultural people believe the best procedure for the farmer in handling metal containers is to triple rinse and puncture the containers and bring to an approved disposal site when they are set up. If there are sufficient sites, both farmers and commercial applicators should bring their containers to landfills. Several dealers felt that landfills were an acceptable practice and that portable crushing equipment should be located at the landfill.

On the other hand, there was opposition to disposal of containers in landfills from several persons because:

- There was insufficient deterioration of containers and pesticides;

- There was insufficient space for good landfills;

- Landfills tend to concentrate the pesticides instead of having them distributed over farms; and

- Landfills were wasteful of the metal resource of most containers.

f. Incineration

Practically all those contacted believed that incineration was an acceptable means of disposal of pesticides provided that air pollution problems did not result. Several felt that incineration was the best means for removal of residues from containers prior to their recycle or reclamation. Most people, however, felt that incineration was too expensive a technique to use for routine disposal of containers (some felt it uneconomical even for pesticides). Only one person we contacted suggested building one or more incinerators in the State.

g. Reuse and Recycling

Most of those interviewed believed that reuse of containers was practical only for 30-gallon and larger metal drums. Several dealers felt that this was an acceptable and needed practice and they would be willing to participate. However, they felt that there were inadequate drum reconditioning facilities available. (In Iowa, large containers are not a popular size in the distribution system.) Several felt that direct reuse would be a problem as a result of labeling, safety, and cross contamination. Others thought that insecticide containers should be reused because they were more dangerous, but that other containers could be disposed of in the local dump or sold as scrap.

There was considerable interest in the recycling--as scrap--of smaller metal containers. For example, one person indicated that crushing and recycling of metal pesticide containers was probably the best solution to the disposal problem since it would conserve resources. He indicated that portable crushing units may be useful but believed that the transportation costs would be prohibitive. He suggested centralized collection points to which crushed units could be delivered, even though this would place a greater burden on the farmer to transport empty containers. He believed that the basic problem was one of logistics; technology was already available.

The staff of a regional cooperative felt that recycling as scrap was probably the most economical and best way to proceed. They also indicated the possibility of portable shredders at dumps and recycling combined with a deposit system might be the best alternative. For example, the recycle operation could be at a local landfill and provide a return of 25¢ per 5-gallon can to the farmer. (Unless the price of scrap increases significantly, the recycle operator could not afford to pay so much per can.) The regional co-op staff felt it would be best to have an industrial organization operate the recycling process and that the state or local government should not be involved in the system. They did not believe either a regional or local co-op should operate landfills or a recycling process but indicated that they would cooperate with whatever systems eventually evolve.

Another co-op expressed interest in operating a pilot project in which they would collect empty containers and pass them on to whomever would clean and recycle the metal in an attempt to determine how well the farmer would cooperate with the system. The co-op operator expressed confidence that most farmers would return the cans, especially those who used significant quantities of pesticides. He indicated that farmers who only used a few 5-gallon cans per year would not be very willing to cooperate.

Another regional cooperative indicated that it would be willing to work with member co-ops to return containers or exchange them in a recycle return process. They believe a large majority of farmers would cooperate. They do not believe that farmers like to litter their fields or place pesticide containers in a location where hazards might result. They believe that most farmers would be willing to cooperate with a recycle or return system just on the basis of economics. Such a system seems to make sense to the farmers, and if the logistics and costs of collection and return could be reduced, farmers would be willing to participate. An independent pesticide dealer believed that scraping of cans would be the most effective way of disposal. He thought that it was a waste of resources to have the metal cans disposed of in a landfill, but admitted that no present scheme for reuse and collection could be profitable in view of the present price of scrap metal. This dealer believed that at some time, scrap metal costs may get to a point where it will become profitable for someone to collect cans.

h. Deposit Systems

In general, dealers, cooperatives and applicators believed that a returnable deposit system--with the containers reused or recycled--might be acceptable. Some felt it would only be acceptable for large metal containers; others felt that small containers should also have a deposit. From the general comments, it was clear that little serious consideration had been given to a deposit system, how it would work, how much it would cost, and how the system would be financed.

For example, a distributor felt that a returnable deposit system would be quite feasible but that the associated disposal activity would probably have to be subsidized to be economically attractive. Typical deposits he suggested were in the order of 15¢ for 1-gallon containers, 50¢ to $1 for a 5-gallon container, and $2.50 for a 30- or 50-gallon drum.

One representative co-op indicated its willingness to cooperate with a disposal system in which farmers would return empty containers to the co-op for a deposit. They felt that it would be advisable to have a deposit for a 5-gallon or larger container of $1 to $3. The local co-op indicated that a deposit system was operating on containers used for selling oil--the deposit for a 15-gallon oil container was $5, $8 for 30-gallon containers, and $10 for 55-gallon drums.

A commercial applicator believed that a deposit of 50¢ would not be acceptable to a farmer; however a commercial applicator would accept a 50¢ deposit or even a 25¢ deposit per can because he uses a large number of containers and it would be easy to collect them in one truck-load.

The agricultural extension service staff do not believe that pesticide dealers want or will accept a deposit system because they feel it will raise the price of chemicals and reduce sales. They also believe that because there are so many sources of supply of pesticides in the State, avenues for collection and disposal with deposits will be too many and too varied to be successful. Another problem mentioned in deposit systems was the need to develop incentives for farmers and others to rinse containers which are being returned under a deposit system. Non-rinsed containers could cause significant health hazards and environmental hazards in the recycle process.

i. Summary

Summarizing the attitudes of various parties towards alternative disposal methods and the acceptance of these disposal methods we conclude the following from our field visits in Iowa.

1. Burning on-site is the most acceptable practice for paper containers.

2. Disposal of metal pesticide containers in landfill, although acceptable to many, is felt by most to be a waste of a valuable resource. Further, disposal of containers in landfill was felt to create contamination problems from concentration of pesticides, particularly because most containers are not rinsed prior to their disposal in landfills or dumps.

3. Reuse or recycle of metal containers would be an acceptable practice, provided however that a simple, practical, and economical means for transport of containers to a recycle facility could be established. A workable method, suited to the specific needs of the state, with its uniform distribution of agriculture and containers has yet to be developed. Although dealers and distributors are ready to cooperate with a recycle or reuse process, they prefer not to operate the process and would like the recycle operation to be conducted by a commercial entity rather than a county or state agency.

4. Incineration of pesticides and/or containers was felt to be acceptable technically but probably too expensive to use except for disposal of large quantities of pesticides.

5. Rinsing of containers is not as well accepted as desired.

6. Other processes such as biodegradation, encapsulation, etc., were not considered practical or feasible in Iowa.

7. Returnable deposit systems, particularly for larger containers, were considered to be acceptable to most people, provided farmers did not have to travel far to return containers and a reasonable deposit was offered. Insufficient consideration has been given to the operation and costs of container deposit systems for their proper evaluation.

9. Environmental Effects

The State of Iowa had been tabulating incidents relating to pesticide and container disposal for less than a year. The following four incidents were reported during the time period July 1, 1974 to January 1, 1975.

- Several empty bags, and one which still contained one-third Dyfonate were disposed of on a brush pile in a pasture. Cattle found these bags, and after licking them, five cattle became sick and two died.

- A mixing barrel of Dioxathion was left in a cattle yard. Although the route of exposure is not known, three cattle died from poisoning by this material and eight showed symptoms of subacute poisoning.

- A bag of lindane had been disposed of on a junk pile surrounded by a fence. Cattle broke through this fence and ingested some lindane, resulting in four dead. Laboratory tests showed residue of 440 ppm lindane in the rumen contents of some of the animals.

- A partially filled bag of Thimet was left in a grove. After ingesting the material, four cattle died and two others showed symptoms of subacute poisoning.

No incidents of health effects to humans were reported.

C. CALIFORNIA--FIELD STUDY

1. Overview of Agriculture in California

The importance of agriculture in California cannot be overemphasized. California farmers produced $7.2 billion in agricultural commodities during 1973; which was 8% of U.S. agricultural production and 6% of the state income. Recent farm income gains have been the result of sharply higher prices, increased production for several major crops, and the addition of nearly 350,000 acres to crop production.

In 1972 approximately 281,000 persons were employed in California agriculture (3.7% of total state employment and 6.4% of total U.S. farm labor), although one job out of every three in the State depended on agriculture either directly or indirectly. Hired labor in California comprises 75% of the total agricultural labor force, while for U.S. agriculture, hired labor is only 26%.

Approximately 36 million acres or 36% of California's total land area is in farms. Of this, 8.4 million acres was under crop production in 1973 and another 25.5 million was in permanent or temporary pasture. While only 12% of U.S. cropland was irrigated in 1969, more than 7.2 million acres, or 88%, of land planted to crops in California was irrigated that year. California has 63,000 farms with an average size of 575 acres in 1973 and an average valuation of $277,000 including buildings. (Nationally, the average farm size in 1973 was 383 acres with an average valuation of $90,960 including buildings.) It is interesting to note that California's 8% of U.S. farm production is produced on only 2% of the nation's farms and on about 3% of the nation's farmland. Due to the high level of mechanization and the wide use of irrigation, many large farms specialize in one or two crops, usually high value crops such as vegetables and fruits rather than the lower value commodities like grain or oilseeds.

Of the over 200 crops produced in California, including seed, flowers and ornamentals, more than 40 are commodities in which California leads the nation in production. A large number of these are specialty crops (e.g., almonds, olives, artichokes, figs, garlic, etc.). Table 28 shows principal California crop production and value. Almonds grow north of Sacramento; cotton, forage crops, grapes, and figs near Fresno in the San Joaquin Valley; and in the wet delta, asparagus, tomatoes, rice, safflower, and sugar beets. Premium wine grapes grow in the Napa and Sonoma valleys north of San Francisco and in adjacent areas. The Imperial Valley in the Colorado Desert in the extreme south, though smaller than the Central Valley, has about 500,000 irrigated acres, much of it devoted to vegetables, barley, and certain fruits. Other major farming areas include the Coachella Valley near Palm Springs, where grapefruit and dates are grown, and the Salinas Valley and Monterey Bay region, noted especially for vegetable production. Oranges are grown primarily from Los Angeles-Riverside north to Fresno.

Table 28. California's Agricultural Commodities: Acreage, Production, Value, Share of U.S. Production, National Ranking, 1973

	Harvested Acreage (1000 acres)	Production (1000 tons)	Value (millions)	Share of U.S. Production (%)	Production National Ranking
Grapes	453.4	3,912.0	609	90.8	1
Cotton Lint	942.2	420.0	395	13.5	3
Hay	1,725.0	7,865.0	385	5.8	3
Rice	401.0	1,129.0	260	24.3	2
Lettuce	141.6	1,746.7	258	70.1	1
Nursery Products	NA	NA	243	18.7	1
Tomatoes, Processing	218.0	4,861.4	200	81.9	1
Almonds	213.7	134.0	193	99.9	1
Oranges	188.8	1,578.8	133	16.1	2
Potatoes	68.2	1,060.4	116	6.2	4
Sugarbeets	265.0	6,440.0	116	26.2	1
Barley	940.0	1,150.6	110	11.3	3
Tomatoes, Fresh	30.8	343.0	109	35.4	1
Cut Flowers	NA	NA	106	22.5	1
Wheat	572.0	926.4	100	1.8	14
Walnuts	161.6	168.0	97	99.5	1
Prunes	81.4	203.0	96	98.8	1
Dry Beans	161.0	135.4	95	16.1	2
Peaches	71.2	857.0	91	65.1	1
Cottonseed	NA	753.0	88	14.4	2
Strawberries	8.1	160.0	84	67.0	1
Lemons	41.1	668.8	84	79.3	1

Source: Department of Food and Agriculture, 1974, "California Agriculture: California's Principal Crop and Livestock Commodities, 1973," Sacramento, California.

Cattle and calves and dairy productions are the two major agricultural commodities in California in terms of value ($1,725 million and $694 million respectively), exceeding any of the field, fruit, or vegetable crops produced in California in this respect. Except for egg production, California's livestock industry does not dominate the national scene as it does for so many of the other agricultural commodities which it produces.

The major cattle producing areas of the State are the Imperial Valley in the south and in Merced, Fresno, Tulare, and Kern counties in the Central Valley. Major dairy producing regions are the counties west of Los Angeles and the central and northern counties of the San Joaquin Valley. The coastal counties north of San Francisco and the northern counties of both the San Joaquin and Sacramento Valleys are the principal areas of sheep husbandry, while poultry products tend to be produced primarily in those areas near the major urban areas of the State such as San Francisco, Los Angeles, and San Diego.

2. Pesticide Use in California

As expected from the size and diversity of California agriculture, the use of pesticides in California is extremely widespread and the volume applied is quite large. In 1973 California's Pesticide Use Report indicates that 183.7 million pounds of pesticides of all varieties were used in the State. This figure includes both agricultural and non-agricultural uses; however, it does not include those quantities of non-restricted materials which were applied by farmers rather than commercial applicators. (A large number of chemicals are classified as restricted use in California. Permits are required for the possession and use of these materials.) Consequently, total usage in California in 1973 is estimated between 200 and 220 million pounds. Chemical industry representatives indicate that 1974 usage should be similar to that of 1973.

In fiscal year 1973-74, the cost of all pesticides used in California was $273,000,000. However, this includes all home and garden pesticides and products such as Lysol and Chlorox. Approximately 47% of this total, or $128.3 million, was used in California agriculture. In recent years, California has typically used 20-22% of all pesticides applied for agricultural purposes in the United States (excluding Puerto Rico, Hawaii, and Alaska).

The largest total market for pesticides in California is fruit, vegetables, and horticultural crops. However, on a crop basis, the biggest single market is cotton. One chemical industry representative we contacted felt that nearly half of all agricultural pesticides used in California in recent years was applied to cotton. However, usage patterns do change from year to year depending on the shifting severity of various crop pests.

Approximately 85% of all acreage treated by pesticides in California is treated by commercial applicators. About 60-70% of pesticides are applied by aerial applicators. The proportion of aerial treatment is generally very high on field crops and vegetables. On the citrus and other fruit crops, pesticides are generally applied by farmers or commercial applicators using ground equipment. There are a large number of aerial applicators in the State who operate from 1 to 30 planes and/or helicopters.

Tables 29 and 30 indicate the quantities of restricted pesticides reported by the California Pesticide Use Report in 1973.

3. Pesticide Distribution System

Although the pesticide distribution system in California may appear quite complex, there is a basic flow pattern which is quite simple and atypical of the rest of the U.S. Figure 3 provides a detailed flow diagram of the system which moves chemicals from the basic producer to the end user.

Of the approximately 40 manufacturers (basic producers) of technical pesticides in the United States, few actually produce the materials in California. Several basic producers have plants in California which further process technical materials prior to their formulation. Both technical materials and finished pesticide products are shipped into California to the State's formulators. The formulators not only combine materials into pesticides, but frequently act as distributors and dealers. Most dealers do not formulate but simply purchase finished products from the formulator and/or the basic producer for sale to applicator or farmers. Many applicators buy directly from the formulator (and occasionally the basic producer), bypassing the dealer entirely.

There are several examples in California where the basic producer controls the flow of pesticides from manufacture to their ultimate application on an agricultural crop. Union Carbide's Soil Serv, Inc., in Salinas, and Shell Chemical Company's Western Farm Service, Inc., in San Ramon, act as formulators, distributors, dealers, pest control consultants, and applicators. These firms purchase technical materials and pesticides from basic producers other than their respective parent companies as required to meet the varied demand.

Unlike many other states, cooperatives do not play a significant role in pesticide distribution process in California. Farm Bureau has affiliated outlets handling farm supply items in most counties. However, the quantity of pesticides moving through these stores is limited. In citrus growing areas, Fruit Growers Supply Service, associated with the Sunkist marketing cooperative, services some cooperative members' citrus groves. The quantity of pesticides handled in this manner also seems to be limited.

Table 29. Usage of Restricted Materials[1] - California, 1973

	Restricted Material (Major Uses)	Quantity (1000 lbs AI)
1.	Methyl bromide (lettuce, tomatoes, sugarbeets, alfalfa, cotton)	36,649.1
2.	Chloropicrin (watermelon, strawberries, fallow ground, non-agricultural areas)	10,579.9
3.	Toxaphene (cotton, tomatoes, beans, lettuce, alfalfa)	2,903.9
4.	Parathion (almonds, orange,s peaches, cotton, lettuce, tomatoes)	1,952.0
5.	Carbaryl [Sevin] (tomatoes, cotton, grapes, corn, sugarbeets, peaches)	1,335.4
6.	Methyl parathion (almonds, artichokes, tomatoes, cotton, lettuce, sugarbeets)	1,204.0
7.	Chlordane (structural and residential control, orchards, grapes)	1,030.0
8.	Methomyl (lettuce, tomatoes, sugarbeets, alfalfa, cotton)	968.5
9.	Phorate [Thimet] (wheat, sorghum, barley, sugarbeets, cotton, corn)	886.3
10.	Endosulfan [Thiodan] (lettuce, tomatoes, alfalfa, celery, grapes)	808.3
11.	Paraquat (cotton, non-agricultural areas, fallow ground)	374.0
12.	Mevinphos (Phosdrin) (lettuce, alfalfa, celery, brussel sprouts, strawberries)	386.9
13.	Azinphosmethyl (Guthion) (peaches, tomatoes, pears, oranges, potatoes, cotton)	384.7
14.	Ethion (grapes, melons, apples, oranges, pears)	346.5
15.	Disulfoton (Di-Syston) (sorghum, potatoes, cotton, alfalfa, tomatoes, broccoli)	278.1
16.	Aldicarb (Temik) (cotton, sugarbeets)	213.4
17.	Azodrin (cotton, potatoes)	211.0
18.	Sodium Arsenite (grapes, state agencies)	123.8
19.	Dieldrin (structural control, grapes, tomatoes, wheat, lettuce)	117.3
20.	Carbofuran (Furadan) (alfalfa, rice)	106.6
21.	Carbophenothion (Trithion) (almonds, grapes, walnuts)	82.7
22.	TEPP (alfalfa, almonds, cotton, grapes)	73.9
23.	Monitor (cotton, potatoes, broccoli, cabbage, cauliflower)	72.2
24.	Phosphamidon (walnuts, oranges, turf, other citrus)	71.2
25.	Aldrin (corn, structural control, sugarbeets)	57.8
26.	Demeton (Systox) (grapes, alfalfa, sorghum, brussel sprouts, cauliflower)	43.6
27.	Sodium Arsenate (sugarbeets, non-agricultural, grapes)	23.0
28.	Lindane (residential and structural control)	13.9
29.	Strychnine (alfalfa)	13.2
30.	Endrin (cotton)	10.7
31.	Bidrin (cotton, alfalfa)	9.5
32.	Arsenic acid (pears)	8.6
33.	EPN (beans, alfalfa)	8.0
34.	Supracide (alfalfa)	5.9
35.	Benzine Hexachloride (BHC) (residential cotnrol)	3.0
36.	Zinc Phosphide (sugarbeets, grapes, non-agricultural)	1.9
37.	DDT (citrus)	1.3
38.	Heptachlor (structural and residential control)	0.8
39.	Arsenic Trioxide	Minimal

Table 29 (Continued)

Restricted Material (Major Uses)	Quantity (1000 lbs AI)
40. Avitrol	Minimal
41. Starlicide	Minimal
42. Diaflor [Turak]	Minimal
43. Sulfotepp	Minimal

[1]The pesticides included in the table are designated as restricted material and their use and possession are subject to special restrictions under regulations of the California State Department of Food and Agriculture. A permit from the County Agricultural Commissioner must be obtained for the use and possession of these materials.

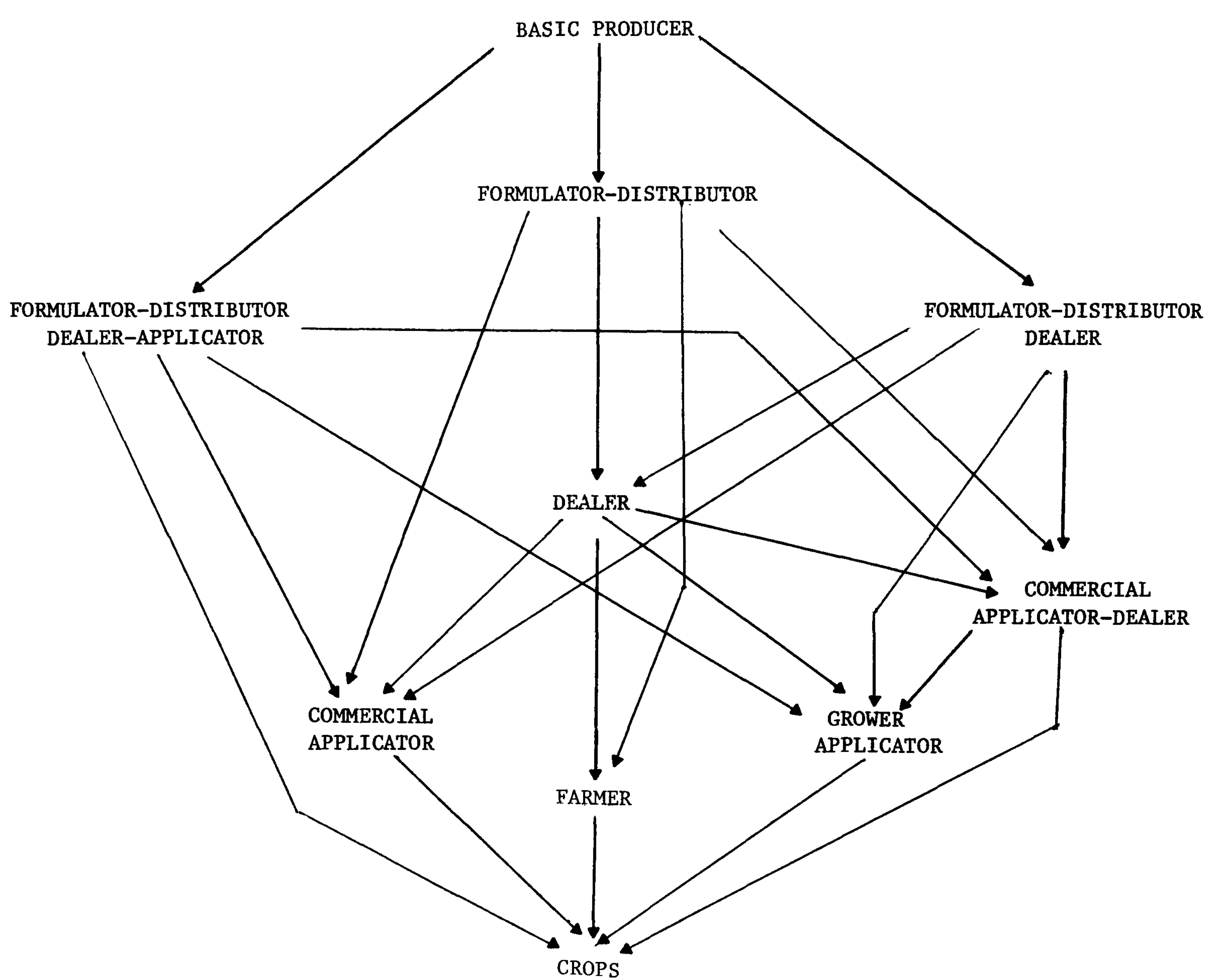
Source: California Department of Food and Agriculture, 1974, Pesticide Use Report, 1973.

Table 30. Usage of Restricted Herbicides
California, 1973

Herbicide (Major Use)	Quantity (1000 lbs AI)
2,4-D (Barley, wheat, sorghum, non-agricultural uses)	1,192.0
MCPA (Rice)	283.3
Propanil (Rice)	83.4
2,4-DP (Barley, pasture, non-agricultural uses)	39.7
2,4,5-T (Pasture, rangeland, alfalfa, non-agricultural uses)	38.9
Silvex (non-agricultural uses)	18.8
Picloram (Non-agricultural uses)	1.0
Dicamba [Banvel]	Minimal

Source: California Department of Food and Agriculture, 1974, Pesticide Use Report, 1973.

Figure 3. Pesticide Distribution System in California



Although most commercial applicators in California do not act as dealers, in remote areas of the State where the distribution system is limited, many applicators do sell pesticides to farmers who then apply the chemicals themselves. Farmers often purchase pesticides but never actually take possession of them. They purchase chemicals from a formulator and/or dealer who delivers the pesticides to a commercial applicator contracted by the farmer to treat his crops.

The wholesale distributor, who simply moves pesticide products between two levels of the production--distribution chain without actually altering the pesticide in some way, does not exist in significant numbers in California. The creation of this level of the marketing system has occasionally been attempted, but never with particular success.

Pest control operators and government agencies generally purchase pesticides directly from formulators; they buy only small quantities from dealers.

In 1974 there were about 1150 formulators, 1350 dealers, and 1550 applicators in California. There is an overlap between each category since formulators may be both dealers and applicators, and applicators may also be dealers, etc. These numbers were estimated from information provided by the Western Agriculture Chemical Association and the Agricultural Chemicals and Feed Branch, California State Department of Food and Agriculture.

4. Magnitude of the Pesticide and Container Disposal Problem

a. Number and Types of Containers

Current estimates of the types and quantities of pesticide containers used in California can be found in Table 31. The source of the 1974 estimates indicated that the estimates should by no means be considered definitive, but rather should be considered rough approximation of the number and type of containers existing in California. Note that there are considerable differences in the number and type of container between the two estimates.

A significant development in pesticide handling in California is the movement toward increased use of plastic containers. Union Carbide estimates that by the end of 1975 as much as 50% of their liquid pesticides will be sold in plastic containers. This company is presently test marketing to determine the acceptance of plastic containers. Although most handlers of pesticides may not object to plastic containers, there are indications that applicators may resist their introduction, particularly for restricted materials, since they believe plastic containers appear to present greater disposal problems for the applicator than do metal or glass containers.

Table 31. Estimated Number of Pesticide Containers in Use, California, 1969 and 1972

	1969 (1)	1972 (2)
55-gallon metal drums	8,000	8,000
30-gallon metal drums	98,000	50,000
5-gallon metal containers	346,000	400,000
1-gallon: metal, glass, plastic	172,000	800,000
1-5 lbs paper sacks		850,000
5-10 lbs paper sacks		2,500,000
10-49 lbs paper sacks	3,247,000	250,000
50 lbs paper sacks		2,000,000
TOTAL	3,871,000	6,858,000
(Small) Home and Garden containers: 1/2 are glass		10,000,000

Source: (1) Rogers, P.H. and Cornelius, J. "Tentative Guidelines for Safe Handling and Disposal of Used Pesticides in California," Cal. Dept. of Public Health, Cal. Dept. of Agriculture (June 1970).

(2) Joseph Shumacher, Agricultural Chemicals and Feed Branch, California State Department of Food and Agriculture, Sacramento, California.

b. Quantities of Pesticides Requiring Disposal

There has been no definitive investigation of the quantity of unused or unwanted pesticides requiring disposal in California. State, industry and private sources contacted in our field study indicated that they believed there were only limited quantities for disposal, except for outdated or recently banned materials.

c. Pesticide Application and Container Disposal Problems--Case Examples from Different Agricultural Sectors

Pesticide application practices vary widely in California depending on the crop (or animal) being treated, the size of the farm, the location of the farm in the State, and the nature and severity of the pest being treated. Because of these widely divergent practices, the quantity and type of pesticide containers or unused pesticides requiring disposal also varies considerably. Although a description of one or even several application/disposal situations could not cover all the practices and conditions found in California, a descriptive summarization of several actual pesticide application "operations" in California is useful to understand the pesticide and container disposal problems.

Small Farmers

Small farmers (less than 100 acres) in California tend to apply their own pesticides. Although this may vary from crop to crop and between regions, most pesticides not applied by commercial applicators are applied by small farmers. Normally the small farmer purchases his liquid chemicals from a local dealer in 1- and 5-gallon containers. Seldom does he handle more than 40 to 50 pesticide containers in a year (excluding oil containers and containers for other non-toxic materials). With this small volume of hazardous materials, his storage and disposal problems do not--on the surface--appear great. However, the small farmer probably causes a large number of pesticide handling and disposal problems which are neither detected nor prosecuted.

Owner/Applicator

The pesticide "operation" described below represents a corporation which owns and manages approximately 2400 acres of citrus in southern California. They perform all their own pesticide application work and work for various "member owners" who have citrus acreage not considered part of the corporation. The firm is also a licensed pesticide dealer, but the only chemicals sold are those used to spray the "member owners'" groves. The company purchases their chemicals from several formulator/dealers in the area. They use large quantities of Parathion and Dimethoate.

The firm uses five ground rigs for spraying, operated by seven men plus one foreman at two locations approximately 75 miles apart. The firm annually handles approximately 300, 50-gallon containers and 50 to 75, 30-gallon drums. Additionally they use numerous paper sacks and one-gallon plastic and glass jugs.

The corporation typically has only a very small amount of unused pesticides for disposal. Normally if a pesticide becomes "obsolete" for their operation, someone can usually be found who has a use for the chemical. Thus, the unwanted pesticide is sold or traded to this person or firm. Rinse water from containers may or may not be emptied into spray tanks for eventual use. However, if the chemical is expensive, draining racks are employed before rinsing of the containers takes place. The material collected in this manner is then used as any other pesticide.

Commercial Applicator

The firm represented in this section is a commercial applicator specifically treating only citrus. The company is a licensed pest management advisor, pesticide dealer, and applicator. It is responsible for pest management on 3-5,000 acres including 400 acres which belong to the owners of the firm. (The operation is a father-son business which hires 10-15 additional persons to operate and maintain the spray rigs.) Although the company is a pesticide dealer, they actually sell only a very small quantity of pesticides to persons whose groves they do not treat. Essentially they are dealers to improve their purchasing position, and to permit them to sell directly to those customers who do not wish to purchase the chemicals themselves.

The company operates 12 ground spray rigs. Their facilities consist of an office building, chemical warehouse, repair shop, and small storage shed. Most of the spray equipment is well-used, if not old. The operation appears quite typical of most medium-sized farmer and commercial applicator operations.

The company does not handle large quantities of pesticide containers. In a year, they will use 250 to 300, 5-gallon containers and 20 to 30, 30-gallon drums. In addition, a few 55-gallon drums are used as well as numerous one-gallon and paper containers. Perhaps 40% of their pesticide volume is packaged in paper containers. The head of the company prefers to use powder materials over liquids. Apparently when the powder or dust spills, either on the individual, ground, or equipment, it is more noticeable than the liquids since clothing, equipment, and ground may all be wet from the water being mixed. Being more noticeable, personnel are generally more conscientious in taking precautions to avoid or clean up the spilled material.

The maximum protective clothing or equipment worn by the spray rig operators appears to be only gloves when handling certain chemicals. Seldom if ever are respirators used, and it seems that no protection is used when empty containers are handled for disposal. Apparently, however, the company has a good safety record in handling pesticides.. Infrequently, someone will require hospital treatment for a day, but this generally has resulted from spraying during unusual weather conditions rather than from handling containers or unused or stored pesticides. Although he did not object to a closed system for handling pesticides, the head of the firm did voice two concerns about such a system. First, since rigs vary so considerably in type and size, it will be difficult to devise a closed system adaptable to all rigs. Second, a closed system would increase application costs; already customers are complaining about the high cost of treatment. Apparently he did not feel that the hazards to employees really warranted a closed system.

The company hauls chemicals to the field or spray site in a caged truck and then returns the empty containers, bags, and partially used containers in the same truck. Mixing of chemicals occurs both at the site of application and the base operation. Probably 70% of their spray jobs are inspected either at the mixing site or spray site (more often the latter) by representatives of the County Commissioner's office. The firm's spraying operations occur over a radius of approximately 100 miles outward from the home base.

The company's facilities are enclosed by a fence. However, this fence also encloses an unrelated citrus packing house and a small lumber yard-mill with no division between the three operations. Although pesticides are stored in a locked warehouse at night, during the day the warehouse remains open. There are no restrictions to prevent employees of the other two operations from visiting the spray mixing and container storage sites.

Integrated Pesticide Firms

The companies represented in this description act as pest control advisors, distributors, dealers, applicators, and formulators. Each of these operations annually treat 300 to 750,000 acres. Generally they own their own ground spraying equipment and subcontract their aerial work to various aerial applicators. These firms operate out of as many as ten locations throughout the state and cover several thousand square miles of cropland. One such operation has approximately 100 mobile spray units, five fixed-wing aircraft, and 10 warehouses with locations as far south as Bakersfield and as far north as Atwater. In one year one of these integrated pesticide operations may handle 5 to 10,000, 30- to 55-gallon drums (more than the statewide estimates given earlier), 10 to 20,000, 5-gallon containers, and innumerable one-gallon and paper containers.

Rather than operating their own application equipment and facilities, many large farmers (1 to 20,000 acres) will contract with the integrated firm to monitor and treat all pest buildups. In other instances, the farmer will do his own monitoring and then contract with the integrated firm to treat the pest when a threshold level is felt to have been reached. In this latter situation, the farmer will generally purchase his chemicals from the integrated firm.

Due to the size of their operations and the diversity of crops they treat, these integrated firms have a relatively stable level of pesticide sales and applications throughout the year. Those crops most commonly treated will be cotton, vegetables, and various field crops.

These firms receive most of their technical grade materials for formulation in 30- and 55-gallon drums. When selling their in-house formulated pesticides or those pesticides formulated elsewhere, they generally do so in 1- and 5-gallon containers. In addition, they sell large quantities of pesticides in paper containers; however, these are manufactured and packaged elsewhere.

Generally when subcontracting spray work to an aerial applicator, the integrated firm delivers the pesticide to the airstrip. The applicator will then bill the farmer directly for the application service, while the integrated firm would charge the farmer only for the pesticides used and for the pest consulting service employed.

5. Status of Regulations and State Policies

Regulations promulgated by the State of California are very specific concerning the disposal of unused pesticides and the transportation, handling, storage, and ultimate disposal of pesticide containers. The State has established and approved three classes of landfills for solid waste including pesticide disposal.

Class I--provides complete protection, at all times, for "the quality of ground and surface waters from all wastes deposited therein and against hazard to public health and wildlife resource."

Limited Class I--a special case of Class I site "where a threat of inundation by greater than a 100-year flood exists."

Class II-1--may overlie or be adjacent to usable groundwater; artificial barriers to both vertical and horizontal leaching are required; protection from a 100-year frequency flood must be provided.

Class II-2--may have vertical and lateral continuity with ground water but provides protection to water quality.

Class III--inadequate protection to ground water.

Pesticides, unrinsed containers and bags can be deposited at Class I sites only. There are 17 Class I sites in the State, however only 12 of these sites will accept pesticides and containers. These are: Big Blue Hills (Fresno), Calabassas (L.A.), Hollister (Hollister), Hunter (Santa Barbara), J&J Disposal (Benicia), Omar Rendering Co. (Chula Vista), Otay (San Diego), Palo Verdes (L.A.) Simi Valley (Ventura), Stringfellow Quarry (Riverside), West Contra Coasta (Richmond) and West Covina (Wilmington).

Only rinsed pesticide containers and bags and cartons may be disposed of in Class II-1 dump sites. There are about 20 Class II-1 dump sites in California. The operators of the dumps can inspect material coming in and are required to charge a fee (levied by the State) for the disposal of hazardous wastes.

Specific state regulations pertaining to pesticides and containers are summarized below.

- Unused pesticides--any pesticide which cannot be used must be disposed of in a Class I dump. With prior agreement, it may be returned to the registrant.

- Transportation--no pesticide or containers may be transported in the same compartment as food items. All containers must be secured to the vehicle in order to prevent accidental spillage or loss of containers during transport. Paper bags, cardboard containers and the like must be covered to protect them from moisture.

- Handling--all metal, plastic or glass containers, which contained less than 28 gallons of a liquid pesticide shall be triple rinsed according to the following guidelines.

Size of containers	Amount of rinse water for each rinse
1 gallon or less	1/4 of volume
5 gallons	1 gallon
over 5 gallons	1/5 of volume

  Rinse water is to be drained into the mix tank. Containers should be allowed to drain for 30 seconds after each rinse. After rinsing, metal containers should be punctured at the top rim to allow remaining liquid to drain out. All containers should subsequently be punctured, broken or mutilated so as to make it impossible to use the containers for any purpose.

- Storage--any empty containers as well as pesticides must be stored in a locked enclosure on the user's property. The area must be posted with suitable warning signs in English and, if necessary, another language. Containers may also be stored in designated holding sites prior to final disposal.

- Disposal of pesticide containers--rinsed pesticide containers may be disposed of in approved Class II-1 dumps, or be contributed to a recycle program approved by the Department of Food and Agriculture. Unrinsed containers, of 28 gallons or more, may be sold to a reconditioner (approved by the Department) or taken to a Class I dump. Paper bags and cartons may be burned in small quantities at the site of use.

Drafts of procedures and practices for the reconditioning of used pesticide containers have been prepared. Several reconditioning processes are specified, one for any gauge metal container and another for 16 gauge or lighter. Safety precautions are emphasized. Reconditioned containers may be reused for the same chemical class of pesticides previously contained, but may not be used as food, feed, beverage, drug or cosmetic containers.

The State Water Resources Control Board and the Regional Water Quality Control Board are responsible for approving and classifying the various dump sites.

The State has developed a system for enforcing these regulations. All farmers and commercial applicators must obtain a permit to possess and use restricted materials. These permits are issued by the county agricultural commissioners and must be presented when purchasing pesticides.

The day prior to applying pesticides, the applicator must file a "Notice of Intent to Apply Injurious and Regulated Pesticides" with the county agricultural commissioner's office. These forms are checked and a master list of all applications in the county is prepared from this.

Field inspectors visit the various farms where spraying is being done. An inspector can appear at any time to view the operation. He checks for adherence to all regulations regarding pesticide storage, handling, use, and disposal (e.g., triple rinsing). If regulations are not being observed, the inspector issues a "Notice of Violation" to the offender. A violation can be handled in various ways, depending on the circumstances.

- A first violation serves primarily as a warning to the individual.

- If a particular user receives several violations, the county agricultural commissioner usually "talks" to the violator.

- If a user, primarily a commercial applicator, has received violation notices in different counties, the State Department of Agriculture will deal with the violator.

6. Current Disposal Practices

As indicated earlier, California has an established well-defined procedure for the disposal of pesticide containers. Basically, all containers of 28 gallons or less must be triple-rinsed, punctured, broken or otherwise rendered unusable, and transported to an approved landfill. Paper bags may be burned in small quantities at the site of use. Larger containers, i.e., 30- and 55-gallon drums, may be sold to approved scrap dealers or reconditioners. In our field study in California, we contacted people active in all phases of the use and disposal of pesticides to ascertain how well the system functioned. Rather than attempt to generalize actual disposal practices, we present here a series of descriptions and scenarios of representative actual disposal practices obtained from these discussions.

State and County Representatives

State and county agricultural staff believe the approved disposal system is working reasonably well and that good cooperation is generally obtained from the applicators, dealers, distributors, etc. They believe that the triple-rinse program, which has also been advocated by the Western Agricultural Chemical Association (WACA) has been accepted in general.

Formulators, Distributors, and Applicators

While county and state officials believe the program is working quite well, the practices we encountered in our field interviews show some variety. One formulator/distributor (who also operates a small application service) reported the following disposal practices:

- 1-, 5-, 15-gallon drums--triple rinse, crush and haul the cans to a Class II-1 dump site.

- 30- and 55-gallon drums--most of the 55-gallon drums are picked up by a cooperage firm (however, the firm is not licensed to accept pesticide containers and will no longer be able to recondition pesticide containers after January 1, 1975). Some drums are used for storage at the formulating operation. Thirty-gallon drums are steam cleaned and resprayed. Drums containing "toxic" materials are sold to a salvage firm. This company also sells spray oils in 30-gallon drums. They charge an $8 deposit for the drum which is steam cleaned and repainted for reuse upon return. About 75% of their customers return these drums. The company does not accept empty containers sold by others.

Another formulator/distributor/commercial applicator triple rinses the 1- and 5-gallon containers. The containers are returned to the central location where they are stored (in a locked yard). About once every two weeks one of the company trucks takes them 40-45 miles to a Class I site.

This company uses the drums originally containing active ingredients to store formulated products. When these drums are no long usable they are taken to a scrap dealer. Any excess drums are sold to a cooperage firm. This formulator also receives materials in 55-gallon drums made of high-density polyethylene. There is a deposit on these drums. The formulator must pay the freight cost to get the drum back to the manufacturer for "reconditioning."

A third formulator/applicator was somewhat different from the others in their practices and operation. They handle about 5000, 30- to 50-gallon drums and about 8000, 5-gallon cans. All containers used in their custom applicator service are returned to the facility where they are washed with caustic soda, crushed, and stored for eventual disposal at a Class II-1 landfill. Paper products are baled and then taken to a dump. (The company contracts with a disposal service to haul the containers to the dump.) The firm will accept empty, triple-rinsed containers from their customers which they will crush and put in their storage for hauling to a dump. The 30- and 55-gallon drums sometimes are used for storage of formulated materials. At other times they are cleaned out and sent to a scrap dealer.

This company also formulates a pesticide which is packaged in a 1-gallon plastic container. They would like to have the containers returned, unwashed, so that the container can be reused. They have obtained the permission of the county agricultural commissioner to dispense with the triple-rinse required by law. Part of this stems from a desire to prevent cross-contamination and the fact that the material is anhydrous (hence, the desire to avoid water in packaging). They refill the container and, if necessary, relabel it; no rinsing or reconditioning is done. The container lifetime is about 2 years.

A firm which owns and manages large citrus acreage as well as a "licensed dealer" and applicator reports the following disposal practices.

Glass containers are usually rinsed once, broken, and put in a dumpster which is periodically hauled to the local landfill. (The landfill is neither an approved Class I or II site.) Five-gallon metal containers have holes punched in them after emptying and are then allowed to drain for several hours. (The draining area is not secured except at night.) After draining, these containers may or may not be washed; if they are, only one rinsing occurs. The containers are then crushed by hand if only a small quantity is accumulated. Otherwise, a bulldozer is used to crush them. A year's supply of crushed containers is collected before they are bought to a Class II site 15-20 miles away. (The nearest Class I site is 30-35 miles distant.) Thirty-gallon drums are delivered back to the formulator for reuse. However, the option exists to sell the drums to a reconditioner for approximately $1.00. The reconditioner steam rinses them and uses a cautic rinse. The reconditioned drums are then generally used for petroleum spray containers.

Some paper sacks are burned, but most are put in the dumpster for disposal at the local landfill. The production manager stated that the firm had authorization from the Agricultural Commissioner's office to dispose of the bags in this manner. Plastic containers are a difficult disposal problem. The 5-gallon plastic container is especially attractive for various personal uses by employees. Consequently, these containers have a habit of disappearing. As a result, company instructions are that the containers are to be irreparably damaged after emptying. One-gallon plastic containers are easier to destroy than are the 5-gallons. After damaging and often without rinsing, all plastic containers are hauled to the local landfill. [The description of disposal practices is for the firm's main spraying operation. Their second facility, approximately 75 miles away, apparently has greater difficulty in disposing of its containers.]

The county agricultural commissioner's staff does inspect the corporation's pesticide application operations. Apparently the most common violations recorded by the inspectors are incorrect, damaged, or missing labels.

The company attempts to find users for unwanted pesticides and will trade or sell them. Several years ago, a local chemical firm volunteered to pick up unwanted pesticide and the company was able to dispose of material that had accumulated over a long period of time.

Another small pesticide owner/applicator who uses about 250, 5-gallon cans and 20 to 30, 50-gallon drums per year, reported the following procedures.

The triple rinse method for cleaning small pesticide containers is used with the rinse water put back in the spray machine. Containers are rinsed with a hose rather than a jet rinse and they are often not drained prior to rinsing. They are punctured rather than crushed. Plastic containers are handled the same as metal, but at this time there are far more metal containers than plastic.

A 1 to 1 1/2 ton truck which has four high wooden sides is kept on the premises. All empty, rinsed containers are thrown into the back of this truck to await hauling. Periodically they are disposed of at a nearby Class II dump (3-4 miles away). No estimate was made as to the number of trips that are made to the dump in a year.

Almost all the large drums are recycled in one form or another. Some go to barrel reconditioners. However most go back to a local formulator (15-20 miles away). Whenever 3-4 empty drums are ready, the formulator delivers the next order of chemicals and picks up the drums. They are apparently reused for the same chemical. The owner/applicator felt this was a good system as long as the formulator was not at too great a distance. Several large drums are used for trash barrels. These drums had held banned chemicals; and consequently, the formulator did not want them back.

Empty bags are disposed of by two methods: burning in the field (only occasionally) and disposal with the other empty containers. In most cases empty bags are returned from the field in a truck and then thrown into the refuse truck described above. The bags are not cleaned in any way and are disposed of at the Class II site along with the rinsed containers.

One aerial applicator we visited indicates that he impresses on his employees the necessity of triple rinsing, but does not feel that it is done most of the time because it is too time-consuming. He handles 70,000 to 80,000 containers per year, of which about 50,000 are 5-gallon and the rest mostly 1-gallon. He contracts with a disposal service to pick up the containers at his various locations.

Farmers

As mentioned earlier, most pesticides in California are applied by commercial aerial or ground applicators. Although we contacted only a few farmers, we asked county officials and applicators for their views of typical disposal practices of small farmers. In general, most persons feel that although the small farmer has relatively small quantities of pesticides to store, his security arrangements are motivated less by regulatory pressure than they are by the fear of theft and the resulting financial loss. Pesticides are usually stored in a tool room or general supply shed; only occasionally do special facilities exist for pesticide storage. When empty, containers are seldom triple rinsed and containers may not be rinsed at all prior to disposal.

The disposal of empty containers and unused pesticides by small farmers may not conform to state regulations governing disposal. Some containers will be washed by conventional means and then will be used in some manner around the farm--trash bins, feed or water containers for animals, feed scoops, water bottles, storage containers, etc. Other containers and unused, unwanted pesticides are apt to be buried on the farm. Small farmers will often take their empty containers to unsupervised or lightly supervised dumps for disposal. These are generally not Class I or Class II sites, but local sites used for the disposal of general trash and rubbish. There are people with small trucks who visit farms and either pay the farmer for them or are paid by the farmer to haul the containers away. Once the containers are obtained, they may be placed in a pile, doused with fuel oil or kerosene, burned, and then sold to junk dealers as scrap metal. There are, however, a number of small farmers who do follow state regulations and thus dispose of empty containers and unused pesticides in the prescribed manner.

Disposal Site Operations

We obtained information on one Class I site. The facility has been in operation since Fall 1973 and is opened twice each year for about 10 days each time (in April and October). In the past, it has been used for "emergency" dumping requirements. Notices of opening are placed in various newspapers and pest control newsletters, direction signs placed, and an access road opened. A bulldozer is rented, and an operator and foreman estimate load size, levy charges, and supervise the operation. The dump has processed between 4000 and 7000 cubic yards of material during its openings. Upon closing, all refuse is covered with a minimum of 1 foot of earth. The fence around the site is locked, the access road is closed and all the direction signs are taken down. All personnel wear protective clothing and the bulldozer is decontaminated with bleach at the dump site. The ratio of crushed to uncrushed pesticide containers received at the site is 1 to 4.

We also visited a Class II-1 landfill and interviewed the operator. He was very leery of accepting pesticide containers because he had an accident with a load and was in the hospital for several weeks. Now he carefully inspects all loads and, if anything is wrong, he will not allow them to be dumped.

Disposal Contracting Firms

There are a growing number of organizations in California which handle hazardous waste disposal. For example, one firm we visited will pick up pesticide containers and bring them to a central location where they are washed with caustic and crushed. The containers are then taken to an approved landfill. If the containers have not been used for "hazardous" materials (e.g., carbamates, phosphates), they are rinsed and sold for scrap. The firm is interested in handling disposal for county-wide areas on a continuous, contract basis. They believe that holding sites should be established, probably at the dump, for the containers. The sites would have to be a locked enclosure, have drainage protection and be posted. (The state solid waste staff has developed criteria for approving holding sites.) The company would then take two trucks to the site, one for rinsing containers and one for crushing and transporting the containers to the dump.

Another firm we visited is not currently involved with pesticides and pesticide container disposal but is interested in entering the field. They have conducted a survey of 400 local farmers and applicators. Ninety percent of the respondents favored the holding site concept. They are investigating two possibilities: (1) hauling to a Class I site or (2) shredding and bailing metal containers for sale as scrap. They hope to start this program in the near future.

Cooperage Firms and Drum Reconditioners

Although several cooperage firms and reconditioners have been operating in the State to recondition pesticide drums, only a few were approved by the State to handle pesticide drums as of January 1, 1975 when the regulations pertaining to reconditioners became effective. Typical procedures are described below.

Drums are picked up at the user's location and must have the bungs on tight. Drums are processed on arrival because a storage facility does not exist. The actual reconditioning process involves the following steps:

1. Rinse with hot caustic (from one to three times);
2. Cut tops of drums off and "curl" cut edge to make it safe;
3. Burn in an incinerator at 1700-1800°F;
4. Steel shot-blast;
5. Reform (to remove dents);
6. Test;
7. Lids are reformed;
8. Paint; and
9. Dry.

After the initial washing, the materials handling is done by mechanical means. The process requires 3-4 hours. The drums then go to an industry which does not deal in food, feed, cosmetics or pharmaceuticals (as specificed by state law). One reconditioner has a contract with a formulator. He sells most of his reconditioned drums to a paint dealer. Drums that are not suitable for reconditioning are rinsed with caustic and sold to a scrap dealer. The reconditioned drums can be used between 8 and 13 times, depending upon the treatment by the user.

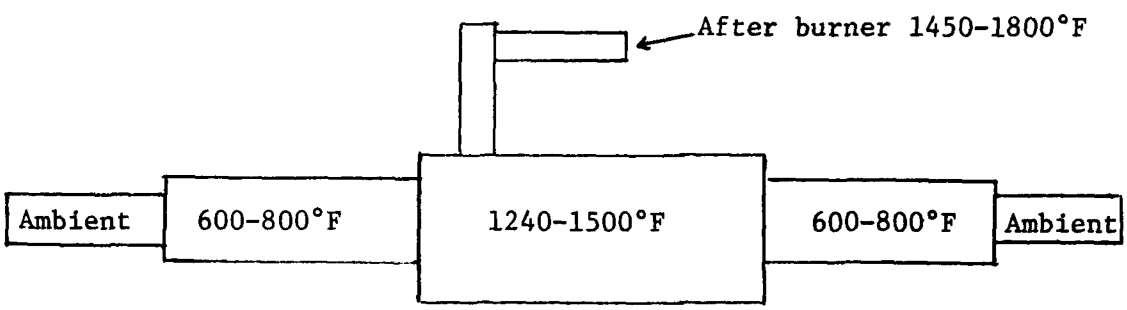
Another cooperage firm/reconditioner provided the following description of current practices.

- Drums are brought to the plant and stored in a special area if they cannot be processed immediately. The storage area is designed with a special surface, special collection systems to handle runoff and a 12-foot high fence topped with barbed wire to prevent unauthorized entrance.

- The drums are rinsed three times with a solution of hot caustic soda and sodium gluconate.

- The tops of the drums are cut off and the edges beaded in a unit that can handle 50 drums/hour.

- The drums are sent to a five-stage burner, diagrammed below.



The unit is 90-120 ft long and can process 400 drums per hour.

- The drum and lid are steel shot blasted in a unit that can handle 400 drums/hour.

- The covers are reformed in a press that can handle 200 covers/hour.

- The drums are placed on an expander to "take out the dents." One of these units can process 200 drums/hr.

- Each drum is tested in a unit that processes 200 drums/hour.

- The drums and lids are painted, both inside and out.

- Finally, the drums go to a drying oven.

Another drum reconditioner operated three plants in the San Francisco area. Two major processes are used. "Tight head" reconditioning involves washing with caustic and rinsing. "Open top" reconditioning involves rinsing, passage through an incinerator operated at 1200-1400°F for 1 1/2 to 2 minutes, cooling, grit-blasting, and painting. The company accepts only pesticide drums which are "certified as decontaminated." These may only be triple rinsed. The company keeps track of the drums it receives from major formulators or manufacturers and returns the reconditioned drums to the specific formulators or manufacturers. Most of the reconditioning is done with 55-gallon drums. The company will pick up drums if there are a sufficient number in any location, or collects drums from scavengers.

Holding Areas

Several counties have established holding areas for the storage of pesticide containers prior to disposal. Some of the sites were originally set up as part of a "container collection compaign" initiated jointly by the State and the Western Agricultural Chemical Association to remove unwanted containers from the area. Several thousand empty containers are located at some of these sites. In some counties not having Class I or Class II-1 dumps, holding areas are periodically opened so that farmers and applicators have a temporary disposal site. Several counties are now negotiating with disposal contractors to operate these sites; others are attempting to have reconditioners or cooperage firms purchase the stored containers. Some of the major pest control operators (commercial applicators) have applied for permission to operate holding areas for containers to improve the logistics and economics of the disposal operations.

Disposal of Pesticides

Unused pesticides appear to be of less consequence in California. Several years ago the State ran a program to collect unused pesticides and many users got rid of them at that time. County agricultural commissions will often accept small quantities from individual users. They store the pesticide and, when there is enough, transport it to a Class I dump.

Commercial applicators try to avoid situations which lead to large, unusable quantities. They usually apply the pesticide in the recommended manner (if not illegal) or take it to a Class I dump as required by law. Although most dealers reported little problems with pesticide disposal, one dealer/applicator we visited indicated that he had at one time about 7 or 8 tons of unwanted pesticides. Most of these contained arsenic, lead, or mercury. He also had surplus of other chemicals that no longer had valid registrations.

Other Views of Disposal Methods

Aerojet Corp. and North American Rockwell have proposed incinerators for the disposal of pesticides and/or containers. Most persons in California who had been informed about these systems believed that the high cost of incineration would be unacceptable. To our knowledge, these proposals have not been accepted by any organization in their disposal operations.

Although the above discussion of our site visits generally suggests that the state approved system for container disposal was being practiced, we were left with some skepticism on the extent to which all containers were disposed of within the system. We were informed by several industrial participants and applicators that "not all containers were disposed of in the officially approved manner." It was indicated that "all the metal containers used could never be accounted for in Class I and Class II dumps" and "many scrap dealers sell shredded or compacted scrap from pesticide containers overseas." This view is supported, in part, from data obtained from county agricultural commissioners and pesticide dealers. We checked the records in one county of the containers disposed of in the only Class II-1 dump site in the county. (Records of the quantities of containers dumped are kept along with the fees charged.) The number of containers disposed of was far less than the number sold by the largest dealer in the county. There were several other major dealer/applicators in the county. Further, one dealer/applicator indicated that he disposed of many containers in the local Class II-1 dump, and few records of his using the dump could be found. This information suggests that pesticide containers do reach "non-approved" channels for disposal.

7. Cost of Disposal

Because the pesticide container disposal operations are relatively highly developed in California, we were able to obtain cost information from a number of applicators, disposal site operators, etc. The cost of current disposal practices is summarized below in four principal categories: crushing and landfilling; reconditioning; disposal services; and costs of deposit systems.

Crush and Landfill

Typical costs of crushers, provided by several persons are as follows:

Type	Cost	Remarks
5-gallon cans	$ 1,100	More than 100 cans/day
5-gallon cans	1,162	1 can per minute
5- and 30-gallon cans	1,500 ("homemade")	11, 5-gallon cans/min.
55-gallon cans	7,988	

The cost of a typical compactor/bailing machine, to handle bags and plastic bottles, is $15,000. The cost of shredders to handle 180 cans per hour is between $15,000 and $20,000.

Cost data for landfills included actual fees charged at Class I and II sites as well as estimates for the development of new sites.

State fees for hazardous wastes are imposed at Class I dump sites. For uncrushed containers, the fee is $ .60/ton. The minimum fee is $1.00. On a volumetric basis the charge is $1.00 for up to 20 cu yd and 5¢ for each additional cu yd. There are about 12 cu yd/ton of uncrushed containers. Crushed containers, averaging 3 cu yd/ton, are assessed at $0.60/ton. For loads of 5 cu yd or less, a minimum fee of $1.00 is charged; any additional volumes cost 20¢/cu yd. These fees cover reporting costs. In addition to the state fee, the Class I dump charges 75¢/cu yd for disposal.

The operating cost for one of the Class I dumps for 10 days is estimated at $5200-6200. Based on the amount disposed of in a typical period, this operating cost is about $1.55/cu yd. The original cost to establish the Class I site was approximately $12,000, including $3200 for land, and the remainder for excavation, roads, etc. This facility has a capacity for 40-50 years use at current rates. Estimates for land (alone) for new Class I dumps in other counties are as high as $50,000-$75,000.

The charges for a typical Class II-1 dump, operated by a private contractor, are:

$1.50	1000 lb
2.00	1000-2000 lb
3.00	2000-3000 lb
3.75	3000-4000 lb
4.50	4000-5000 lb
5.25	5000-6000 lb

The minimum charge is $1.50 and a permit is required for loads in excess of 2000 lb. A 10% surcharge is imposed on non-county residents.

Reconditioning

One drum reconditioner located in the Los Angeles area pays 50¢ per drum for any drums picked up "below Fresno" and 25¢/drum "above Fresno." They also charge freight costs. Reconditioned, open-top, black drums sell for $9.65 for a 55-gallon drum and $7.90 for a 30-gallon drum. Tops cost $1.00 and rings, $1.25. Colored drums are more expensive. The costs of the reconditioning process were "confidential."

Another cooperage firm gave the following costs for various components of his present reconditioning system.

Item	Drum Capacity	Cost
Drum Cutter & Edge Beader	50/hr	$50,000
Five-stage Burner/Incinerator Equipment	400/hr	$400,000 (exclusive of installation)
Fuel		$ 60,000/year
Water		$ 3,000/year
Drum Body Shot Blaster	400/hr	$ 75,000
Drum Expander	200/hr	$ 30,000
Drum Tester	200/hr	$ 25,000
Painting Equipment	--	$100,000
Dryer	--	$ 60,000
Materials Handling Equipment	--	$100,000

This facility can handle several thousand drums/day.

This firm is designing a new plant to process 9000 drums/day. The capital investment is estimated to be $5 million, plus 23% contingency, with an addtional $1.5 million for real estate.

This cooperage firm buys drums for $.75-$1.00, depending on the condition. The cost of reconditioning a drum is $1.75-$3.25. Pesticide drums cost more to recondition than ordinary drums due to the additional treating involved. The drums are sold for $6.00-$6.50. There is a 4-5% scrap loss and the average drum life is 9 reuses.

Disposal Services

Several disposal services handle pesticide containers on a one-time basis. Following are typical disposal prices:

1.	Rinsed, 1- and 5-gallon cans Unrinsed, 1- and 5-gallon cans	25¢/can 30¢/can
2.	5-gallon can 30-gallon can	20¢/can 35¢/can
3.	all cans	$3.00/first 1000 lb $1.00/each additional 1000 lb

The firms are willing to enter into contracts with the counties for disposal on a regular basis, or with applicators and farmers.

Deposit Systems

There are companies in California which have or participate in some type of deposit system. One distributor charges a deposit of $8 on each 30-gallon drum of spray oil or weed killer. The returned drums are steam cleaned, at a cost of $3/drum, and reused. Another distributor requires a $10 deposit on these types of drums.

A drum company is manufacturing a 55-gallon drum of high-density polyethylene. The deposit on these containers is $15. The customer is responsible for returning the drum to the plant, i.e., the customer must pay transportation costs.

A formulator has a returnable container (1-gallon, plastic) but does not require a deposit on it. The container itself costs $2.50.

8. Attitudes Toward and Acceptance of Disposal Methods

a. General Attitudes and Acceptance

The attitudes of the persons contacted in California toward pesticide and pesticide container disposal may be somewhat different than those encountered in other states because California has a highly structured, regulated, and enforced disposal system. Two types of general attitudes were prevalent. First, and that most commonly found, was that pesticide and container disposal could indeed be a problem, the State had passed reasonable regulations to reduce the problem, and the regulations could and should be complied with. Most applicators, dealers, and others involved in pesticide distribution and use felt that although the procedures may be time-consuming and costly, they could be accomplished and would prevent unwanted adverse environmental and health effects.

The other general attitude, expressed by a few participants in our field survey, was that pesticide and container disposal did not become a "problem" until regulations were passed. Prior to that time, pesticides and containers were disposed of through "normal channels" with very little environmental and health problems.

Applicators and pest control operators, who are the largest user group of pesticides in California, generally believe that the state enforced disposal system was operating adequately. They feel that greater emphasis should be placed on reuse of larger containers, primarily through returning them to formulators or through drum reconditioners. They were not in favor of deposit systems since it added considerable bookkeeping and costs to their activities.

Pesticide dealers and distributors were generally opposed to any system which would return containers through their inventory or processing. They believe that it is the primary responsibility of the user to dispose of containers. They prefer to see the user bring pesticide containers to a disposal site or have disposal contractors pick them up. They were not in favor of the deposit system because of the added bookkeeping and inventory problems. Most were willing to become "disposal centers" only if it were required by regulations.

We expect that individual farmers would prefer to dispose of containers on their own property rather than to bring them to disposal areas. However, our sample of farmers was insufficiently large to determine this adequately.

Several people discussed the opportunities for another class of service business in the pesticide industry--the pesticide container service that takes unrinsed pesticide containers, rinses them, disposes of rinse water, and takes the containers for reuse or other reclamation. Pesticide disposal contractors felt that it was the responsibility of the manufacturer and distributor to communicate the proper method of disposal to the consumer. They also believe that they will play a more important role in disposal in the future.

Another interesting attitude of some individuals was that the types and sizes of pesticide containers may ultimately be established by OSHA regulations which limit weight of containers for handling. They expected that industry would move towards 15-gallon containers as the largest size for easy handling. They also indicated that most industrial people are trying to reduce the number of 1-gallon and perhaps 2-gallon containers and move towards a 5- and 15-gallon container size.

Several industrial people also believe that bulk shipments would become more important, particularly where they can be combined with closed pesticide delivery systems. This would help eliminate some container disposal problems.

Several pesticide distributors felt that the continued increase in the use of large returnable plastic containers would help solve some of the disposal problems but could create others. The problem of rinsing and crushing steel containers and health problems related to scrap and reuse would be partially solved. However, problems of contamination using plastic containers, and the ultimate disposal of plastic containers, may be more serious than those with the steel containers. In general, drum reconditioners have mixed feelings toward the use of plastic drums. Although it will affect their steel drum reconditioning business, many of them will move towards reconditioning plastic drums.

Many applicators believed that "closed systems" will become a more widespread practice. In closed systems, containers have special openings requiring appropriate tools for entry and mechanisms to prevent unauthorized persons for putting substances back into the container except the manufacturer. Small containers are not used; contact with pesticides and containers is minimized. Closed system of containers would be advantageous in large spray applications. Several pesticide applicators indicated they would be willing to pay up to several thousand dollars to convert to closed systems. They believe this would considerably reduce the number of containers to be disposed of, eliminate to a large extent the occupational hazards of applying pesticides, and save labor.

Some small operators had objections to closed systems, although they concluded they would help solve the disposal problem. Some of the objections are that spray rigs were often quite different from one another, and, as a result, it may be very difficult to devise a closed system adaptable to all or most rigs. Second, the cost of converting the spray rig to a closed system adds to the cost of application which is undesirable in today's economy. The same objection would be raised by the small operators towards a deposit system.

b. Burning and Incineration

Most of those interviewed believe that burning of small amounts of paper pesticide containers was appropriate and safe. There is some discrepancy among the local regulations on container burning. For example in one county, farmers must have 5 acres of land or more in order to burn containers. The general feeling is that paper bags or cardboard should burned provided only a few are burned at one time or burning is not done in heavily populated areas.

Most people believe that incineration is a necessary part of the container recycle process, that it should be used for disposal of excess pesticides, but that it is an expensive process.

c. Triple Rinsing of Containers

Although there is a general belief among the State Department of Agriculture staff that the triple rinsing process has been accepted reasonably well, enforcement has probably been the principal reason for its acceptance.

Nevertheless, several state people are skeptical of the acceptance of the triple rinse method. They claim, for example, there is no effective way to tell whether a container has been rinsed once, twice, or three times. They feel that most people indicate they rinse the container three times but really do not. Discussions with applicators and farmers indicate that containers are often rinsed only once and that inspection of spraying operations is one of the principal reasons rinsing is done at all.

d. Landfills

Members of the several county agricultural commissions indicated that landfills were the "best and cheapest way to take care of the problem of pesticides and containers." Most applicators and dealers were not adverse to landfills, but believed recycle or reuse was better.

Users of landfills were not entirely satisfied with their operation. For example, several people felt that the greatest difficulty in the current landfill disposal system in California was Class I sites. Because of the remote and distant location of several Class I sites, and the few periods in which they are open for acceptance of pesticides and containers, pesticide users either have to travel long distances or hire outside parties to move containers and materials. It was felt that pesticide users often handle and store pesticides and containers in an acceptable manner, but the persons who carry or haul pesticides to landfills have little knowledge of pesticides and do not take appropriate precautionary measures. Others felt that the distribution of landfills was inadequate. For example, in some counties there are three Class II-1 facilities and perhaps several Class I facilities. In other counties there may be neither type of disposal facility. Any system which is designed to provide the pesticide user with disposal sites must take into account the distribution of containers and users. The general attitude is that most users will not travel very far to reach a disposal site, even if it is contrary to regulation.

Several pesticide disposal site operators are hesitant to accept loads of pesticide containers because they do not believe they were rinsed. The incidents where health hazards have occurred, although few, have apparently made many disposal site operators leery of pesticide containers.

e. Holding Areas

Several members of state and county agricultural staff believe that holding areas operated by the counties are not acceptable, They believe that if such holding areas were readily available, they would be deluged with persons attempting to leave pesticides and containers there and that these could have a serious health and environmental impact.

On the other hand, several applicators and distributors felt that holding areas operated by the county or private concerns would be helpful. Holding areas would eliminate the problem of having the distributor handle pesticide containers more than once and would not involve him in the return. If sufficient holding areas were located throughout the state, consumers would know that there is a nearby place where the container could be deposited safely until the containers could be recycled or reused.

f. Reuse and Recycle

Because reuse and recycle is already prominent in California, it was not surprising that these systems found considerable acceptance.

Concerning reuse of containers, one of the major integrated pest control companies we visited believes that the returnable container system would best suit their needs. Although they currently contract for disposal in landfills, they believe that either a returnable system or one in which pesticide containers are reconditioned or sold as scrap is more useful. They believe that the environmental and health hazards involved in the recycling or reconditioning process could be minimized and that resources could be conserved. Several other distributors are looking forward to the increased use of large plastic containers which can be reused.

On the other hand, state and county staff did not believe that a system whereby the container is returned to the manufacturer or distributor is workable except for returnable plastic containers.

The general view of the cooperage firms and drum reconditioners was that their business will probably become more profitable in the future. Some believe that whereas now they pay farmers and applicators for empty pesticide containers, in the future farmers and applicators may pay them for collection of the individual containers. Cooperage firms generally would not prefer the reusable container or the deposit system since they now make considerable profit from their operations. One drum reconditioner we contacted suggested six areas where attention is needed in drum reconditioning; transportation, storage, mechanics of reconditioning, employee exposure, residues, and ultimate reuse. Although he did not give specific recommendations in each of these problem areas, he believed that a coding system for containers by a combination of painting and embossing of symbols should be accomplished. The embossing could be done along with the DOT classifications. He felt that it should be against the law to remove the embossed designations. This way both the reconditioner and the user can be certain that a pesticide container does not enter beverage, feed, or other channels where exposure could be a problem. Such a system also could be used to help assure that containers were used and reused for similar chemicals. He also suggested that all containers, 30-gallon or larger, should be reconditioned.

Cooperage firms and reconditioners did not believe that small containers could be reused. Instead, these companies and many dealers and applicators felt that scrap metal companies will probably become more important in the pesticide disposal process. Rather than bury small metal containers in a landfill, they feel the best solution would be to have counties operate holding areas and have applicators and farmers bring rinsed and/or crushed pesticide containers to the holding area. A scrap dealer or other disposal contractor would then collect and recycle the containers. Most people believed this could be a profitable operation for counties as well as for the scrap dealers and could present a reasonable solution for the pesticide applicators or farmers. One of the problems is assuring rinsing of the containers, but even if they are not rinsed, most people feel that the hazards involved would be relatively small. It was felt that if only scrap dealers collected the pesticide containers, they would soon become knowledgeable of the hazards involved and be able to rinse out containers in their own facilities with minimum difficulty. Only one reconditioner we contacted felt that pesticide drums or containers should not be used as scrap because of the hazards involved.

g. Deposit Systems

Attitudes toward deposit systems were mixed. Several state staff members believe that a returnable deposit system would be very valuable. They suggested that associating dollars with containers would make containers a more valuable commodity and thus they would be handled in a more reasonable fashion.

Several applicators believed that a deposit system should be developed. It was mentioned that deposit systems are now used on pallets and oil drums and work well. One applicator favored a uniform, reusable deposit system which he described as similar to that currently in use with "beer kegs." He indicated that such a deposit system could use a color coding or other markings in a more direct and straightforward manner than the current markings and labelings and suggested that a uniform standard of codings and markings be adopted among pesticide producing and marketing companies.

Another formulator, distributor and custom applicator we contacted is already involved in a returnable deposit system for large plastic drums. Although they pay a $15 deposit on these drums and freight costs for returning them, they adhere to this process because it is most economical for them at the present.

Another major dealer believed that large containers, 30-gallons and over, should be reconditioned and reused and suggested that a deposit of $9-10 might be appropriate, in view of the cost of new drums of $10-15. He was not sure of the feasibility of the deposit and/or recycle system in view of the high cost of transportation and the possible large distances between users and reconditioners.

A reason given by several dealers who would not like a deposit system is that they have relatively small storage facilities for containers they would have to handle in a deposit system. They suggested a recycling system where farmers bring containers to an appropriate collection point and receive a deposit payment. The general consensus of dealers was that the recycling with a deposit system should be done through drum reconditioners or through scrap dealers rather than through pesticide distribution systems.

9. Environmental Effects

The State of California has been compiling data on the fish and wildlife losses caused by pesticides for over ten years. Examples of the reported accidents caused by disposal of pesticide containers include:

- On September 7, 1971 a five-gallon can of "Hydrothol 191" was found dripping into a drain near Richvale, California. Over 1000 fish were killed (mostly carp).
- In a stream near Mather Air Force Base an extensive fishkill was noted in 1964. Nearby, it was found that pesticide containers were being emptied of leftover material by military personnel at the Air Force Base. Enough toxic material entered the stream to kill fish for several miles.

Overall, state personnel feel that the number of accidents caused by pesticide containers is minor compared to other causes of pesticide-related accidents. Furthermore, with the implementation of the state disposal regulations, it appears that the number of accidents from container or pesticide disposal is decreasing.

D. MISSISSIPPI - FIELD STUDY

1. Overview of Agriculture in Mississippi

The importance of agriculture to Mississippi's economic structure has been decreasing for the last 25 years. Although agriculture's contribution to total industrial based earnings in the State has remained about the same dollar value since 1950 ($500 to $600 million), the percentage contribution has declined from about 30% in 1950 to a projected 10% in 1980.

Agricultural employment accounts for about 113,000 persons (15%) of the labor force employed in major agricultural sectors in Mississippi. Approximately 85,000 of the farm workers are classified family labor while the remaining 28,000 are hired labor.

The number of farms in Mississippi decreased nearly 50% during the period 1959-1969, from 138,000 to 73,000. During this same period, average farm size increased from 135 acres to 221 acres (64%). In general, this shift can be interpreted as a movement to more highly capitalized, mechanically efficient farms with a heavy reliance on purchased inputs including pesticides.

Only 27,100 farms (37%) in Mississippi are classified as commercial farms, i.e., with annual sales over $2,500. About one-third of these specialize in cotton or cash grain, the majority of the remainder emphasize livestock and mixed family operations. The relative importance of the agricultural production sectors in Mississippi has been quite constant in recent years with crop production and livestock production contributing about equal proportion to the state's total agricultural income.

Crop production in Mississippi is dominated by cotton and soybeans. During the period 1971-73, these two crops accounted for approximately 80% of the harvested cropland acreage in the State. Cotton production in Mississippi averaged nearly 14% of total U. S. cotton production in the years 1971-1973. Cotton production requires about 30% of Mississippi's harvested cropland acreage. Mississippi is said to possess an economic advantage in cotton production (compared to Texas and California) with average yields considerably above the national average due to favorable soil and climatic conditions.

Since 1950, soybean acreage in Mississippi has steadily increased until it is now the major crop in the State in terms of cropland utilized. Soybean acreage occupied nearly 50% of harvested cropland in the period 1971-1973. Soybean yields in Mississippi are reported to be nearly 25% less than U.S. average yields. However, the restrictions on cotton acreage by government controls in the past and by the restrictions of the present market necessitate an alternate crop to cotton, especially on the land least suited for cotton production. Soybeans have proved to be more profitable, even at relatively low yields, than any other major crop available to Mississippi farmers. Total soybean production averages about

4% of total U. S. production.

A summary of Mississippi crop acreages, yields and crop production is presented in Table 32, along with comparisons to total U. S. production.

The dominant livestock activity in Mississippi (about two-thirds of total livestock income) is beef cattle production. Sales of hogs, dairy and poultry comprise the bulk of the remainder of livestock income. Beef cattle operations in Mississippi are primarily cow/calf and back grounding operations. No large-scale feedlot fattening operations are reported for the State. The beef cattle raised in Mississippi are fed primarily on native and cultivated pastures supplemented with locally grown and imported grain and hay.

2. Pesticide Use in Mississippi

An estimated 30 million pounds of insecticide active ingredients were applied in Mississippi in 1974, a 30% increase from 1973.* Approximately 90% of this total was purchased in liquid form while the remainder was in granular, wettable powder or dust formulations. Two insecticides comprise about 85% of the market; Methyl Parathion and Toxaphene with 38% (11.5 million lbs A.I.) and 47% (14 million lbs A.I.), respectively. These two major insecticides are commonly formulated both alone and in combinations, such as:

6# Toxaphene + 3# Methyl Parathion
6# Toxaphene + 1.5# Methyl Parathion

No insecticides other than Toxaphene or Methyl Parathion are believed to possess greater than a 3% market share. The most widely used other insecticides are:

Insecticide	Formulation
Azodrin	Liquid
Guthion	Liquid
Chlordane	Liquid
Endrin	Liquid
Strobane	Liquid
Di-Syston	Granular
Temik	Granular
Thimet	Granular
Sevin	Wettable Powder and Dust

*The source for much of the data in this section was the Mississippi State Extension Service.

Table 32. Mississippi and U. S. Crop Production, Selected Crops, 1973

Crop	Unit	Harvested Acreage (thousand)	Yield Per Acre (unit)	Production (thousand)
Mississippi				
Cotton Lint[1]	lbs	1,340	645	1,800
Corn for Grain	Bu	148	39	5,772
Soybeans for Beans	Bu	2,750	22	60,500
Oats	Bu	20	40	800
Wheat, All	Bu	100	27	2,700
Rice[2]	lbs	62	4,306	2,670
Sorghum for Grain	bu	30	35	1,050
Irish Potatoes late spring	cwt	2	85	170
Sweet potatoes	cwt	9.5	110	1,045
Peanuts[3]	lbs	9.5	1,750	16,625
Hay, All	tons	650	1.86	1,208
Peaches[4]	mil lbs	---	---	10
Pecans, All	lbs	---	---	22,000
United States				
Cotton Lint	lbs	11,995	519	12,958
Corn for Grain	bu	61,760	91.4	5,643,256
Soybeans for Beans	bu	56,416	27.8	1,564,518
Oats	Bu	14,110	47.0	666,867
Wheat, All	Bu	53,875	31.8	1,705,167
Rice[2]	lbs	2,170.2	4,277	92,765
Sorghum for Grain	Bu	15,940	58.8	936,587
Irish Potatoes,All	cwt	1,303.1	228	299,410
Sweetpotatoes	cwt	113.2	111	12,534
Peanuts[3]	lbs	1,495.7	2,323	3,473,837
Hay, All	tons	62,190	2.16	134,608
Peaches[4]	mil lbs	---	---	2,604.9
Pecans, All	lbs	---	---	275,700

[1] Yield in pounds, production 480-pound net weight bales.

[2] Yield in pounds, production in 100-pound bags.

[3] Harvested for nuts.

[4] Production in million pounds (Miss. Prod. in 48-pound equivalents, 1973 (208,000); U.S. Prod. in 48-pound equivalents, 1973 (54,269,000).

Source: Mississippi Crop and Livestock Reporting Service, December 1, 1974.

The majority of insecticide application in Mississippi is on cotton. Typically, cotton acreage will receive eight or more insecticide applications at rates ranging from 0.75 lb/acre A.I. (Methyl Parathion) to 2.0 lbs/acre A.I. (Toxaphene). It is estimated that 80-85% of all insecticide applications in the State is for cotton with 10% applied to soybeans and the remaining 5-10% devoted to minor agricultural and non-agricultural uses.

An estimated 10-15 million lbs of herbicide active ingredients were applied to cotton and soybeans in Mississippi in 1974. Cotton received an estimated 65-75% of herbicide application. Estimates of 1972 percentage of acreage treated by herbicide and by stage of crop growth are presented in Table 33 and Table 34, for cotton and soybeans, respectively. These estimates are based on a survey conducted by the Mississippi State Extension Service for the 80 counties comprising nearly 100% of acreage of these crops.

Precise estimates are not available for fungicide usage in Mississippi. However, based upon fungicide usage rates for cotton and soybeans throughout the U.S., we estimate that the total annual application for this class of pesticide is substantially less than 1 million pounds.

Pesticide usage by the livestock is insignificant. The USDA "Pesticide Review" for 1972 reported only 1% of the value of Mississippi pesticide sales was for livestock usage.

3. Pesticide Distribution System

The pesticide distribution system within Mississippi is relatively simple. A small number of firms supply the pesticide needs of farmers. A flow diagram of pesticide distribution is presented in Figure 4.

This system is typical for distribution of insecticides. Little formulation of herbicides takes place in Mississippi. However, the organizations which act as insecticide formulators also act as the major distributors of herbicides within the state.

Seven organizations perform the majority of insecticide distribution and a large percentage of herbicide distribution:

Table 33. Estimated Percentages of Cotton Acreage Treated With Herbicides by Herbicide and Stage of Growth in Mississippi, 1972

Preemergence Stage

Herbicide	Percentage of Acreage Treated	Herbicide Combination	Percentage of Acreage Treated
Treflan	12.0%		
Planavin	4.0%		
Cotoran	11.0%	over Treflan or Planavin	45.0%
Karmex	6.0%	over Treflan or Planavin	14.0%
Telvar	1.0%	over Treflan or Planavin	5.0%
Herban	.3%	over Treflan or Planavin	1.0%
Caparol	.1%	over Treflan or Planavin	.5%

Total Acres Treated
Preemergence 542,826

Total Acres Double Treated
Preemergence 1,057,392

Postemergence Stage

Layby

Herbicide	Percentage of Acreage Treated	Herbicide	Percentage of Acreage Treated
Herbicidal Oil	4.0%	Karmex	23.0%
Mobilnix	2.0%	Lorox	11.0%
MSMA or DSMA (alone)	40.0%	Cotoran	3.0%
MSMA or DSMA + Herban	6.0%	Other	< .1%
MSMA or DSMA + Cotoran	69.0%		
MSMS or DSMA + Karmex	52.0%		
MSMA or DSMA + Caparol	10.0%		
MSMA or DSMA + Lorox	10.0%		
Dinitro (alone)	3.0%		
MSMA or DSMA + Dinitro	30.0%		
Dinitro + others	5.0%		

Total Acres Treated
Postemergence 3,804,543

Total Acres
Treated Layby 595,691

Notes: Cotton was cultivated an average of 3.6 times.
Total acres planted--1,603,563 (80 counties)

Source: Mississippi Extension Service

Table 34. Estimated Percentage of Soybean Acreage Treated with Herbicides by Herbicide and Stage of Growth in Mississippi, 1972

Preemergence Stage

Herbicide	Percentage of Acreage Treated	Herbicide Combination	Percentage of Acreage Treated
Treflan	31.0%		
Planavin	12.0%		
Amiben	3.0%	plus Treflan or Planavin	3.0%
Dyanap	9.0%	plus Treflan or Planavin	8.0%
Lasso	3.0%	plus Treflan or Planavin	1.0%
Lorox	3.0%	plus Treflan or Planavin	3.0%
Vernam	.3%	plus Treflan or Planavin	<.1%
Solo	..3%	plus Treflan or Planavin	<.1%
Maloran	.1%	plus Treflan or Planavin	<.1%

Total Acres Treated
Preemergence 1,283,408

Total Acres Double Treated
Preemergence 321,606

Postemergence Stage

Herbicide	Percentage of Acreage Treated
Dinitro at "cracking"	24%
Tenoran directed	4%
2, 4-DB directed	9%
Lorox	7%
Wax bar	2%
Other	5%

Total Acres Treated
Postemergence 1,052,492

Notes: 34% of treated soybeans had only one postemergence spray

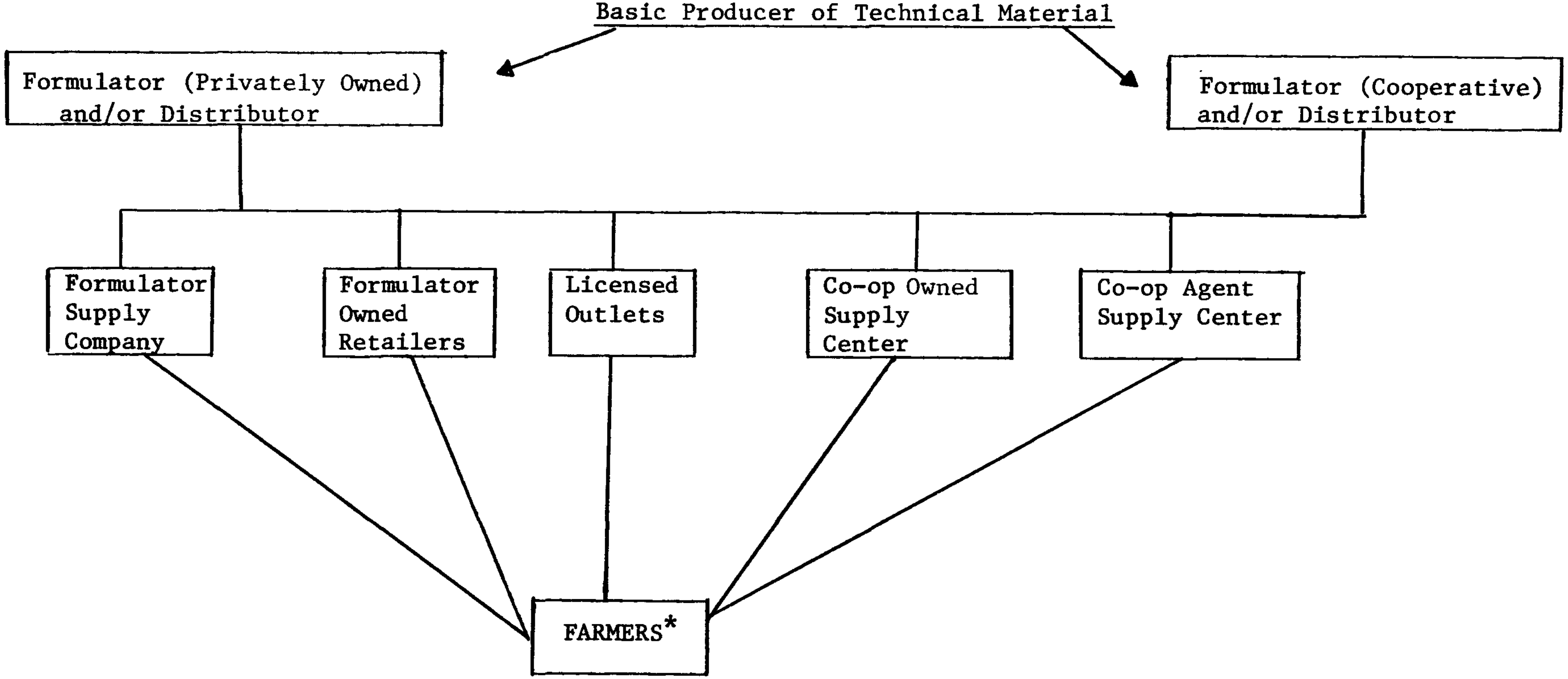
14.4% of treated soybeans had two or more postemergence sprays

Soybeans were cultivated an average of 2.8 times

Total Acres Planted -- 2,103,625 (80 Counties)

Source: Mississippi State Extension Service

Figure 4. Pesticide Distribution System for Mississippi



*Only insignificant amounts of sales are reported to be made to pest control operators.

Organization	Location	Function	No. of Formulating Plants
Staple Cotton Growers Assoc.	Greenwood	co-op form. & distrib.	1
Valley Chemical	Greenville	" " "	1
Helena Chemical	Belzonia	form. & distr.	3
Riverside Chemical	Marks	" "	4
Cleveland Chemical	Cleveland	" "	unknown
Thompson-Haywood	Greenville	" "	1
Miss. Fed. Cooperative	Jackson	distributor	--

Several of these firms also provide entomological consulting services to farmers.

Based upon discussions with representatives of these organizations, we believe that most sales of pesticides are made direct to the large farmer or applicator by the formulator/distributor. Retail outlets serve mainly small farmers and "pick-up" business. The cooperatives and cooperative retail stores often perform only a facilitating function, taking orders, buying in bulk and arranging delivery while never actually having physical possession of the product.

4. Magnitude of the Pesticide and Container Disposal Problem

a. Number and Types of Containers

Estimates of the number of pesticide containers by type in Mississippi are presented in Table 35.

Table 35. Estimated Number of Insecticide Containers used in Mississippi

Container Type	1968	1969	1973	1974
	(thousands)			
55-gal drum (metal)	46.5	65.8	49.1	90.9
30-gal drum (metal)	13.5	16.0	17.0	24.0
5-gal (metal)	185.0	240.0	228.0	334.0
1-gal (glass & plastic	351.0	400.0	775.9	620.0
Other	100.0	115.0	102.1	180.7
TOTAL	696.0	836.8	1172.1	1249.6

Source: 1974 data--ADL estimates based on Bureau of Environmental Health Data. 1973 data--Mississippi State Extension Service. 1968 & 1969 data--Stojanovic, B.U., F.L. Shuman and M.J. Kennedy (1969), Basic Research on Equipment and Methods for Decontamination and Disposal of Pesticide Containers, Mississippi Ag. Exp. Stat.

Detailed information on the number and type of herbicide containers was not available.

A significant development in pesticide handling in Mississippi is the use of bulk pesticide tanks. These tanks, ranging in size from 500-5000 gals, are placed by the chemical company on a large farm, PCO airstrip or central distribution point. Product is metered from the tanks with the chemical company refilling when necessary. The tank may be owned by the pesticide distributor or the farmer. Several companies now have 25-30 bulk tanks throughout the state.

The advantages of using bulk tanks are said to be: elimination of container disposal problems, storage convenience, handling convenience and cost savings. However, bulk tanks are regarded as an experiment. Negative factors cited for bulk tank usage were: high capital cost (tanks and trucks), company liability (for vandalism or contamination), and farmer prejudice.

b. Quantities of Pesticides Requiring Disposal

There has been no comprehensive study of the quantity of unused or unwanted pesticides requiring disposal in Mississippi. Most sources we contacted indicated that they believed the quantities for disposal were small.

c. Pesticide Distribution Practices and Container Disposal Problems--Case Examples

Several examples of the distribution practices of formulators and distributors are discussed below because they significantly impact current and future container disposal practices.

Company A

Company A is a cooperative which serves about 950 large cotton farmers in the Mississippi Delta. Their distribution area is concentrated in the area near their formulation plant. The plant produced 1.75 million gallons of pesticides in 1974. 1.25 million gallons of these pesticides were distributed directly to farmers in bulk tanks located on 52 different airstrips. The size of tanks at these airstrips varies according to the demand, ranging from 1400 to 5000 gallons. Bulk tanks were introduced by Company A in 1970. The bulk tank capacity has doubled every year since.

In 1974 two products were delivered in bulk tanks: a mixture of six pounds of Toxaphene and three pounds Methyl Parathion per gallon, and a three pound per gallon formulation of sodium chlorate. Additional pesticide used on the farm are added directly from small containers to the aircraft spray tanks. Cleaning equipment is available to prevent cross contamination.

The remaining 500,000 gallons of chemical not distributed in bulk tanks are distributed in 55-gallon drums and 5-gallon metal cans, primarily in the 55-gallon drums. Pesticides are distributed from the formulation plant to one of the 17 warehouses used by Company A. Three of these outlets are fully owned and operated; the remaining 14 are operated by selected farm supply businesses. These outlets serve as a pickup point for co-op members. The outlet owners are paid a fee for warehousing, handling and filling orders. The shift to bulk tanks by Company A was motivated by the desire to provide a lower cost to farmers. Since Company A is a co-op and gives patronage refunds to farmers, they feel that they can give higher refunds through the lower cost achieved by using bulk tanks. Company A also has seven entomologists on their staff who provide consulting services to the farmers at no cost. These entomologists also assist the aerial applicators in achieving the correct pesticide mix.

Company B

Company B formulates five principal compounds:

- A four pound per gallon formulation of Methyl Parathion;
- A six pound per gallon formulation of Toxaphene;
- A formulation of six pounds per gallon Toxaphene with 1 1/2 pounds per gallon of Methyl Parathion;
- A formulation of 1.6 pounds per gallon Methyl Parathion with 1.6 pounds per gallon Endrin; and
- A formulation called Defend 267.

Direct sales of these formulations are in:

- bulk tanks (four);
- 55-gallon drums (majority of product);
- 30-gallon drums (small volume); and
- 5-gallon cans.

Company B also sells pesticide through four authorized agents who operate farm supply stores.

Company C

Company C is a privately owned chemical company which operates three formulating plants in Mississippi. Company C distributes pesticide in three ways:

- direct to farmers from the formulating plants;
- direct to farmers from company-owned chemical outlets in several locations; and
- to a variety of farm supply stores and small co-ops.

A large amount of pesticides are delivered directly to the farmers at airstrips. Company C presently serves more than 40 airstrips. Most product is delivered in 55-gallon drums.

Company D

Company D is a large supply co-op. This firm does not own a formulating plant but purchases pesticides from other formulators in Mississippi. Company D sells directly to farmers in 55-gallon drums which account for 75% of their total volume, 5-gallon drums which are about 1/8 of their total volume, and 1-gallon cans which are the remaining eighth of their total volume. Company D is discontinuing the use of 30-gallon cans. Bulk tanks are not used for pesticide distribution. The reasons cited are the possible legal liabilities, the need for pesticide mixtures, a lack of interest by area applicators and the possible fear of being cheated when material is taken from the tanks.

The majority of the Company D's business is what might be called pass-through business which operates in the following fashion. One of the farm supply stores takes orders from a number of farmers and consolidates these orders. These orders are consolidated at a district or a regional office of the co-op which then places an order with a formulator. The pesticides are delivered direct to the farmer by the formulator if it is a large order or by the co-op if it is a small order. In the majority of instances the product is never stored in the Company D warehouse. Aerial applicators do not buy any pesticides from Company D; the pesticides are purchased by the farmers and then used by the aerial applicators.

Company E

Company E is a co-op which owns a formulation plant and has 15 farm supply outlets (warehouses) from which they take and fill orders for co-op members on a fee basis. Major products sold by Company E are a formulation of four pounds Methyl Parathion per gallon and a formulation of six pounds of Toxaphene and three pounds of Methyl Parathion per gallon. This co-op formulated 600,000 gallons in 1974. Fifteen percent of this chemical was distributed through bulk tanks; approximately 8% in 5-gallon cans; and the remainder in 55-gallon drums. This firm does not use 30-gallon drums. Representatives of this co-op stated that the trend is toward greater use of bulk tank for pesticide distribution. Their experience has been that the airstrip operators and aerial applicators "love" the bulk tanks.

Company F

Company F formulates six major pesticides and mixtures in plants in two cities in Mississippi. Farm distribution is carried out in three ways:

- direct to farmers from the plant;
- through 11 farm supply outlets owned by company; and
- to retail dealers such as Independent Farm Supply Bureau and small co-ops.

This firm's goal is to have a retail outlet in every agricultural trade area in Mississippi. Company F is presently increasing its use of bulk tanks and states that they much prefer this method of sale. The company has from 20-30 bulk tanks located throughout Mississippi. The remainder of the pesticide sold by this firm is in 55-gallon drums (70%), 30-gallon drums (2% or 3%) and 5-gallon cans (10%); thus 17-18% of the total is distributed through bulk tanks.

From these examples, it is apparent that bulk tank usage is increasing and that the majority of pesticides are sold in larger containers. Collection and disposal of containers may be easier in Mississippi than in several other states because of the extensive use of aerial application and the direct delivery of pesticides to airstrips.

5. Status of Regulations and State Policies

The disposal of unused pesticide containers in Mississippi is covered under the "Solid Wastes Disposal Act of 1974." Unused pesticides and containers are classified as hazardous wastes and are to be disposed of by means determined by the State Department of Health, the Bureau of Environmental Health.

Containers should be triple rinsed, crushed and buried in an approved sanitary landfill. Larger containers, such as 30- and 55-gallon drums, may be sold to reconditioners. While it is legal to bury containers or paper bags on private property, this practice is not encouraged.

Disposal of unused pesticides must be referred to the Bureau of Environmental Health which is responsible for the ultimate disposition of the material whether it be incineration, soil injection, sanitary landfill, shipment overseas, storage, etc.

6. Current Disposal Practices

a. Disposal of Small Containers

The State of Mississippi's pesticide container disposal program for 1-, 5- and 15-gallon containers and all combustible containers is integrated with the overall solid waste disposal program administered by the Bureau of Environmental Health, a department of the Mississippi State Board of Health. The program operates in the following manner.

- In areas/counties where garbage collection is unavailable, the state places containers for disposal of waste (including pesticide containers), 4 to 6 cubic yards in volume, at locations convenient for any disposer, such as major cross roads, near housing projects, etc. Usually those who need to dispose of solid waste are no more than 2 miles from a disposal container. On the average, there is one container for every 150 people.

- The disposal containers are emptied twice a week. Containers which, by experience, tend to fill up quickly are emptied more often. A diesel engine truck, with a volume of 30-35 cubic yards and a compaction ratio of 4 to 1, is used to empty the container. The schedule in most counties calls for collection of waste in one-half of the county on Monday and Thursday and the other portion on Tuesday and Friday; Wednesday is for maintenance and collection at those sites which require more than two pickups per week.

- All solid waste which is collected is taken to the sanitary landfill in the county. When all sanitary landfills are in operation, no disposal container will be more than 20 miles from the sanitary landfill site. At the sanitary landfill, the solid waste material is spread, packed and covered each day. The sites are also open to the public for disposal of items which are too large to be deposited in the collection containers.

The Bureau of Environmental Health conducts several projects to inform the public about the program. Printed circulars are distributed in all the counties. These outline the various parts of the program and contain a county road map with all container sites located on it. People from the Bureau will speak and present a slide presentation to civic organizations. A program in conjunction with the Cooperative Extension Service has been planned. The program will consist of meetings with farmers in the various counties to inform them about the safe disposal of pesticide containers. The program is only several years old, but the state people feel that it is very successful.

There are several recommended methods for disposal of pesticide containers which come from the Bureau of Environmental Health and from the Cooperative Extension Service. The Bureau of Environmental Health recommends the following procedures for containers up to 15 gallons:

triple rinse all containers (except paper bags);

puncture all cans; break glass containers and remove caps from and slash, cut, or mutilate plastic bottles, and

deposit in solid waste containers along with the household refuse.

Most of the persons we contacted indicated that most users only do "one quick rinse." This is done primarily to get as much out of the container as possible because of the high cost of the pesticide, rather than as a safe practice. Based on observations of the Bureau of Environmental Health staff, most of the cans which are deposited in the solid waste containers have been crushed. Plastic bottles usually have only had the caps removed and are not slashed, as recommended.

Combustible material can also be disposed of in the solid waste containers. However, most users burn these materials at the site of use. This is a violation of state law but very few individuals are ever "caught" and prosecuted or fined for this violation.

The program appears to be effective for container disposal. The farmer can dispose of his empty containers with his other solid waste as opposed to two separate disposal streams. This also eliminates the time-consuming process of digging a pit for burial. State inspectors have noticed a "substantial decrease" in the number of pesticide containers left by the side of the road, on the banks of streams, floating down the river or in other places where they could cause health and safety as well as aesthetic problems. The overall safety of the approach has not been validated.

Another disposal option is presented by the Cooperative Extension Service which distributes a number of publications on the recommended methods for disposing of pesticide containers. This agency recommends the following procedures:

- For combustible containers, including paper bags, fiber drums, burlap bags, cloth bags, cardboard boxes, fiber boxes and wooden boxes, the disposal methods, in order of preference, are: burning in a commercial incinerator; burning in a <u>supervised</u> public or private dump; open burning at the site of use <u>if</u> permitted by local authorities, or crushing and burial under at least 18 inches of soil, away from water, livestock, etc.

- For small, non-combustible containers (glass, plastic, or metal containers up to and including 5-gallon size), "it is strongly recommended that this type of empty container not be reused for any purpose." An exception may be a 5-gallon metal container if "it is deemed of sufficient economic value." The disposal steps are:

  - Wash outside of container with water; rinse inside of container with water containing detergent and caustic soda (sodium hydroxide);

  - Discard rinse solution by burying at least 18 inches deep in an isolated area, away from water supplies;

  - Break glass containers; puncture and mutilate plastic containers; puncture and crush metal containers;

  - Discard in a designated landfill or bury on farm property following recommendations for construction of disposal pit.

These guidelines are in general agreement with those of the Bureau of Environmental Health (i.e., burial in a landfill) with the exception of the desired "treatment" prior to actual disposal and the fact that the Bureau does not mention burial on private property. The Bureau of Environmental Health hopes that their program with the Cooperative Extension Service will bring the two agencies into agreement on the recommendations.

The disposal system described is used primarily by the small farmer. Users of large amounts of pesticides--such as owners of large acreage or commercial applicators--employ different methods of handling container disposal. When they have accumulated a large number of the smaller containers, they use their own truck to transport the containers directly to the sanitary landfill nearest their operation. There is also a disposal service in the northern part of the State which will handle pesticide container disposal for a fee. The service simply picks up the containers at the customer's operation and transports the containers to the state-operated sanitary landfill.

Because this program is relatively new, it is difficult to ascertain how well the program is working and how many farmers and applicators follow the state recommended approach. Most of our contacts indicated that the program was making progress and was "not unreasonable."

The Department of Biological and Agricultural Engineering at Mississippi State University conducted a study in 1970 to ascertain what users did with their empty containers. A summary of their findings is given in Table 36. Those containers which were kept or sold to the public (usually 30- and 55-gallon drums) frequently ended up in such uses as barbecue pits, whisky stills, water troughs, animal feed troughs, etc.

Table 36. Methods of Disposal of Pesticide Containers, 1970

Method	Percent
Buried	18.4
City dump	16.6
Burned	
metal	5.8
plastic or paper	4.2
Kept	15.3
Sold to:	
reconditioner	6.6
public	6.8
Thrown in gully or on farm trash pile	8.9
Crushed	9.5
Returned to dealer	7.4

Source: Mississippi State University, Dept. of Biological and Agricultural Engineering, 1970.

b. Large Container Disposal

The disposal of 30- and 55-gallon drums is just beginning to be handled by the State. In two of the delta counties, the State has established a holding site at the sanitary landfill. Users can leave their empty containers there anytime the dump is open. When a sufficient number of the drums have accumulated, the State calls a cooperage firm in Louisiana. The firm picks up the drums and reconditions them. The money received from the sale of the drums is given to the Boy Scouts. The program has only been in effect since spring of 1974, but, in the two counties over 700 drums have been collected. Plans have been made for similar holding sites in all delta counties by spring, 1975. The program may later be expanded to include all counties, even though there may not be many drums to collect.

The Cooperative Extension Service recommends that 30- and 55-gallon drums be sold to a reconditioner. If this is not possible, they suggest disposal by one of the methods suggested for smaller containers.

Our discussions with pesticide formulators and applicators on disposal methods indicated that drum reconditioners in Mississippi, Louisiana, and Tennessee pick up most 30- and 55-gallon drums at airstrips. Farmers are given cash for the drums, or they may be given a credit by the cooperative or distributor who is paid by the drum reconditioner. The cooperatives usually operate the pickup service at no profit. However, other cooperatives do not participate in the drum return; it is handled directly by the farmer or applicator. Some cooperatives will remove 5-gallon cans from airstrips and bring them to sanitary landfills as a service to the farmer/applicator. The general belief is that most of the larger containers--30- and 55-gallon--are sold to reconditioners; smaller metal containers are sent to landfills.

One drum reconditioner we contacted reconditions the drums via a series of washings with different solutions. The insides are washed eight times and the exterior are washed six. The process is completely automated from unloading of drums through to storing of completely reconditioned drums. Sludge from the washing solutions is burned in an incinerator. The reconditioned drums are not sold for use in the food, feed or cosmetic industry.

c. Disposal of Pesticides

The disposal of unused pesticides is supposed to be referred to the Bureau of Environmental Health. Table 37 summarizes the findings of a study of disposal practices in 1970 (Mississippi State University, 1970). The Cooperative Extension Service recommends the following methods, in order of priority:

- Incineration, if acceptable facilities are available;

- Use for purpose originally intended, if it is not illegal;
- Return to manufacturer or distributor for potential re-labeling, recovery or reprocessing;
- Burial in a specially designed landfill; and
- Temporary storage if none of the above are possible.

Table 37. Methods of Disposal of Unused Pesticides, 1970

Method	Percent
Return to dealer (usually unopened containers)	7.0
Dumped in city sewer system	1.6
Applied to soil surface	15.6
City dump	11.0
Sanitary landfill	6.3
Buried	24.2
Burned	7.0
Stored for possible future use	27.3

The State Environmental Agency will accept these methods if the user has only a small quantity. Large quantities have been handled in several ways:

- Materials should be encapsulated in large concrete "containers" and buried in a sanitary landfill which is equipped with special wells for monitoring for any leakage or leaching of the materials;
- Large quantities of DDT should be sold to foreign countries or to organizations which distribute them for use in under-developed nations; and
- Temporary storage pending a final acceptance disposal alternative (or use if the ban on the material is removed).

Mississippi State University has investigated disposal methods primarily for pesticides but also some for containers. Their research has encompassed three basic areas:

- Microbiological degradation--This process involves the degradation of pesticides (and residual material in containers) by soil micro-organisms. Degradation ranged from almost none to a high of 36%. However, the pesticides were found to cause slight to severe (99%) reductions in the microbial population in the soil. This disposal route is satisfactory for very small amounts or a few cans, but cannot handle large volumes.

- Chemical degradation--The only substances found suitable for detoxifying all major types of pesticides were liquid ammonia and metallic sodium. Both these agents require extreme caution when used and are likely to cause more accidents and environmental damage than the pesticides themselves.

- Thermal degradation--A pilot plant incinerator was built to handle 12 gallons/hour of pesticides. All pesticides were degraded at a temperature above 900°C (1652°F). Containers must be shredded prior to introduction into the incinerator.

Staff of the state university believe that thermal degradation appears to offer the best means of disposal at the present time. Operated in the proper manner with the necessary pollution control equipment, incineration is even more desirable, from environmental and safety standpoints, than landfilling.

One other route of disposal which has been suggested but not evaluated is a combination of microbiological and thermal degradation. In this process, the pesticide (or container) would be partially decomposed by burning at a lower temperature (say 250°C) and then subjected to soil micro-organisms for final decomposing. This would appear better from an energy standpoint than total thermal degradation.

7. Cost of Disposal

Limited cost information was obtained in Mississippi. Staff of the Bureau of Environmental Health provided some cost estimates for the disposal system which they operate in Mississippi. On the basis of one ton of waste disposed, the waste collection containers, storage and pickup costs \$6/ton and the disposal in the sanitary landfill costs \$2.25/ton. Costs of some of the components of the system are:

Waste collection container (4 cu yd)	\$290-295
Truck (32 cu yd)	\$34,000-35,000
Tractor (for landfill)	\$46,000-48,000

These costs are for the total solid waste disposal system not just for pesticide container disposal. The capital investment for a county of 4000 population is about \$88,000.

In the recycle program, which the state operates for 30- and 55-gallon drums, state people quoted the following average prices paid by the drum reconditioner in 1974:

30-gallon	\$1.25
55-gallon	\$2.25

A cooperage firm, however, supplied the following quotes from their current (1975) price list:

Picked up	30-gallon	$1.00
	55-gallon	$1.50
Delivered to Facility	30-gallon drum	$1.50
	55-gallon drum	$2.00

The amount given for a mono-stressed, 55-gallon drum is 50¢. In general prices for drums picked up depend on the distance. The cooperage firm sells the reconditioned drums for $7.50-8.00; this includes delivery to the customer.

Mississippi State University built a pilot plant scale incinerator for a cost of $50,000. The incinerator is designed to burn 12 gallons/hour. Containers must be shredded prior to burning.

8. Environmental Effects

We were unable to obtain any documentation of incidents caused by disposal of pesticides and pesticide containers in the State of Mississippi. In the past, the State has not kept records. A new law which is currently being implemented will require documentation and record keeping of all environmental and safety accidents resulting from pesticides. Documentation of these accidents will allow separation by cause.

E. NEW YORK--FIELD STUDY

1. Overview of Agriculture in New York

Although agriculture is important in the economy of New York, it is one of the less important industries of the state. About 95,000 persons, or less than 2% of the State's labor force is employed on farms, compared to a national average of 5.7% farm labor. An additional 10% of the work force in New York is employed in enterprises directly related to agriculture. Farm income in New York accounted for 0.3% of total personal income in New York in 1972, compared to 2.5% for the U.S. in 1972. Cash receipts from farming in New York from 1971 to 1973, including both crops and livestock averaged $1,200,000,000 per year or about 1.8% of the total U.S. receipts; government payments were about $17,000,000.

Approximately 34% (10.9 million acres) of New York's total land area was devoted to farmland in 1969 as compared to 47% of total U.S. land devoted to farmland. The number of farms in New York is currently estimated at 56,000 with an average size of 195 acres per farm compared to a U.S. average farm size of 385 acres.

The most significant aspects of New York's agriculture is the diary industry. During 1971-1973, New York produced 10.2 billion pounds of milk annually, 8.6% of the total U.S. milk production. In 1973 milk production accounted for 53.3% of New York's gross agriculture income. New York ranks number 2 nationally in the production of milk.

A significant portion of field crop production (hay, corn, oats) is fed to the dairy cows and other animals on New York farms. Fruits and vegetables also account for a significant share of New York's agricultural income. New York ranks number 1 nationally in the production of maple syrup; number 2 in the production of apples, grapes, tart cherries, and snap beans; number 4 in the production of onions and horticultural items.

Milk, beef and veal, and eggs are the significant aspects of livestock production in New York. Milk production in the state roughly equals consumption. However, the state's demand for meat and eggs far exceeds the state's production.

2. Pesticide Use in New York

The state of New York requires that pesticide dealers report their annual sales of restricted chemicals. However, the state has not provided the funds to have the raw data tabulated and published. Knowledgeable people in the pesticide industry and the state government have said that no survey of pesticide usage in New York has been conducted since 1952. Hence, there appears to be no good source of data on the quantities of pesticides used in New York.

Discussions with the Farm Chemicals Division of Agway- the largest farm supply cooperative in the state, has however provided some useful information. Personnel at Agway estimated that they distribute approximately 1/3 of all pesticides marketed in New York. Since Agway serves all types of farmers in the Northeast, their list of top sellers is probably fairly indicative of commonly used pesticides for the state. Table 38 lists Agway's top selling pesticides by type. It should be noted that since New York produces many different types of fruits and vegetables, many chemicals are used in addition to those listed.

Since good data do not exist, it was not possible to determine the relative volumes of insecticide, herbicide, and fungicide usage. However, Agway personnel indicated that in fiscal year 1974, herbicides accounted for about 52% of their total pesticide sales.

Table 38. Pesticides Commonly Used in New York

Herbicides	Insecticides	Fungicides
Aatrex	Guthion	Maneb
Lasso	Sevin	Captan
Princep	Monitor	Benlate
Eptam		
Paraquat		
Premerge		
Lorox		
2,4-D		

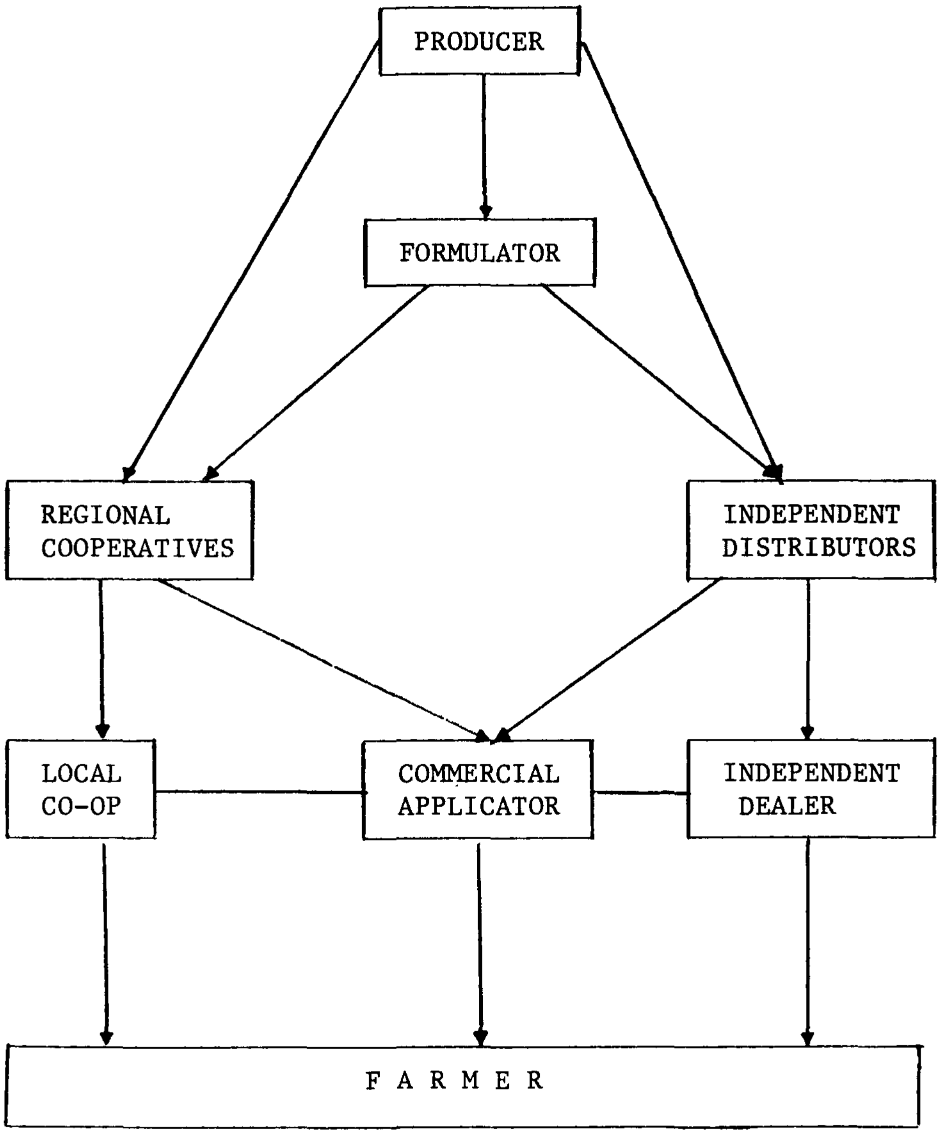
Source: Agway, Inc.

3. Pesticide Distribution System

The pesticide distribution system in New York is shown in Figure 5. The arrows indicate the typical flow of chemicals. There are several exceptions to the flow indicated in the figure. Local co-ops will, on occasion, purchase from an independent distributor; likewise, an independent dealer may purchase from a regional co-op. Also, chemicals will sometimes be transported from a producer directly to a local co-op with the regional co-op serving as an ordering house and transportation.

Some firms perform more than one function in the system, for example, some local co-ops in the state also serve as commercial applicators for their farmers. Likewise, some independent dealers are also commercial applicators. Some farmers serve as commercial applicators for their farmer neighbors. Some private firms wholesale and retail pesticides.

Figure 5. Pesticide Distribution System in New York



Conflicting estimates were obtained from industry personnel concerning the number of producers, formulators, distributors, and dealers in the state. It is generally believed that New York has numerous smaller dealers, distributors and formulators due to the large number of small volume crops produced. Small firms are able to compete by serving a specialty market. Thus, it is not possible to estimate the number of firms in each link in the distribution system.

Personnel in the New York Bureau of Pesticide Regulation indicated that a total of 5,000 firms are registered to handle pesticides in New York. This list includes producers, formulators, distributors, dealers, and commercial applicators. A breakdown of these firms by type was not available.

4. Magnitude of the Pesticide and Container Disposal Problem

No data exist on the number and type of pesticide containers disposed in the state of New York. Table 39 shows the typical types of containers for the more common pesticides referred to earlier. Discussions with industry personnel indicate that roughly 60-65% of all pesticides sold in New York are believed to be marketed in paper bags or cartons. The remainder are sold in 1 gallon or 5 gallon metal cans, 30 gallon or 55 gallon metal drums, 1 gallon or 5 gallon plastic containers, and a few glass bottles.

Since no published data exists on the quantity of pesticides used or the number of pesticide containers requiring disposal each year in New York, it is impossible to estimate the magnitude of the disposal problem. The situation is compounded further by the fact that New York agriculture is quite variegated. Dairying predominates, but many dairy farmers raise a number of different field crops such as alfalfa, corn, oats, winter wheat, and soybeans as well as having considerable pastureland and sometimes wooded land. The pesticide usage pattern of each of these crops is quite different.

On the other hand, a significant number of farmers in New York are engaged in fruit and vegetable production. These farms vary greatly in size and number of fruit or vegetable crops produced. Each of these crops have specialized pest management problems, and varying requirements for pesticides.

5. Status of Regulations and State Policies

Parts 325.5 and 325.6 of the New York State Environmental Conservation Law relate to the disposal of unused pesticides and pesticide containers. Used containers may only be disposed of in approved sanitary landfills, incinerators, or refuse disposal sites.

Table 39. Typical Containers for Pesticides Commonly Used in New York

Pesticide	Container(s)
AAtrex	paper bags
Lasso	metal cans
Guthion	metal cans
Paraquat	metal cans
Maneb	paper bags
Captan	paper bags
Sevin	paper bags
Princep	paper bags
Benlate	paper bags
Eptam	paper bags and metal cans
Premerge	metal cans
Monitor	metal cans
Lorox	paper bags
2,4-D	metal cans

Source: Agway, Inc.

Disposal for combustible and non-combustible containers is as follows:

- Combustible containers- burial or incineration at an approved site or burning, in small quantities, at place of use with permission of the local public health officials.

- Non-combustible containers- rinse at least twice, returning rinse water to mix tank and dispose of at an approved site as listed above. The law does permit the reuse of certain pesticide containers provided they are not for storage of water, human or animal food, cooking utensils, dishes, clothing, and the like. Containers destined for reuse must be rinsed at least twice, tightly sealed and the exterior cleaned. The reconditioning procedure and intended reuse must be approved by the Department of Environmental Quality.

The regulations specify that unused pesticides must be disposed of by burying under at least 18 inches of compacted soil at a location where ground or surface water cannot be contaminated.

There were no approved public landfills which could accept unused pesticides or containers at the time of our survey. The Department of Environmental Quality recommends burial on the farmer's property at a site that is approved by the agency. Unused pesticides may be incinerated by an authorized disposal firm. These guidelines are only temporary until such time as approved landfills are available.

6. Current Disposal Practices

The disposal of pesticide containers in New York State is handled almost totally by burial. The state law requires rinsing, at least twice, and disposal at an approved site or burning, in small quantitites. However, since there were no approved sites in the State during our survey, the Department of Environmental Conservation (DEC) allows burial on the farm at an approved site.

The farmer may either apply pesticides himself or contract with a commercial applicator to apply them. The empty containers, which the farmer has usually rinsed once, are usually buried somewhere on the farm, thrown on a farm trash pile to "degrade" or taken with the household garbage to a local landfill. Even though the on-farm burial sites are supposed to be inspected, no farms have ever been inspected due to a lack of manpower in the DEC. Almost all combustible containers are burned at the site of use. No information was found as to whether farmers contact their local health authorities for permission to burn these materials as is required.

Farmers who contract with a commercial applicator usually are "left" with the containers for disposal. In some cases, however, the commercial applicator may take the containers and dispose of them with his other used containers. When the farmer has supplied the commercial applicator with the chemicals, the farmer will dispose of the empty containers in the same way in which he would if he applied the chemicals himself.

The commercial applicator in New York generally operates on a rather small scale. For example the average aerial operation consists of 1 or 2 aircraft and about 3 employees.

Commercial applicators almost always use combustible containers, disposing of them in small quantities at his place of business or at the location where the pesticide is applied. Containers of the 1 and 5 gallon size are either crushed or broken and taken to a landfill. The applicator usually does not have the time or space to bury them on his property. The 30-and 55-gallon drums generally go to reconditioners. Only few applicators have bulk storage tanks, which reduce the container disposal problem.

There are two drum reconditioners in the state which will accept pesticide drums. They require the user to rinse out the drums and replace the bungs. In the reconditioning operation, the tops of the drums are removed and then the drums are burned at 1500°F, shot blasted (with steel shot), dedented and painted. The drums are then sold to non-food connected industries as prescribed by law.

The New York State College of Agriculture at Cornell University conducts mini-courses for farmers and applicators on the use of pesticides and disposal of containers. Their recommendations are the same as the DEC; in fact, the people at the university work closely with DEC in establishing the guidelines.

There is only one firm approved by the state to handle pesticide disposal. The firm employs incineration as the disposal method. Because there were no approved landfills in the State, DEC did allow other methods of disposal for small quantities. These include use (if not illegal) at the recommended application rate, burial on the farm or storage until a suitable disposal method can be found. In 1975, the State planned to pick up and dispose of all unused pesticides from the farmer and commercial applicators. How this system will be financed and operated is not known. They will probably "package" them and send to the approved incinerator. Cornell handles many inquiries from farmers in regards to small amounts of unused pesticides. The quantities are usually less than 1-gallon, i.e., a partially used container.

Farmers who have unused pesticides will store the pesticides, usually in a locked enclosure, and use it next year in the recommended manner. The New York State College of Agriculture and the pesticide department of DEC regularly receive many calls regarding disposal of unused pesticides. If the quantities are small, they recommend application at the specified r ite. For larger quantities, usually in the possession of commercial applicators or large farmers (of which there are relatively few), they did recommend stor ige but will offer to pick it up. Several years ago, the State College of Agriculture collected a large quantity of unused, banned pesticides (e.g. DDT) and took it to Dow for incineration. They do not plan to do this again because the DEC will soon handle disposal.

7. Cost of Disposal

Information on disposal costs in New York was limited to reconditioning of drums and disposing of unused pesticides. The state will transport, store and dispose of unused pesticides for $1.00/lb. A pollution service, the only one licensed by the state to dispose of pesticides, charges 20¢/lb for bulk material or $80/drum for separately packaged units. This disposal firm handles large quantities and would not take small lots from individual users.

One reconditioner in the state will pay $.75-$1.25 for a 30 gallon drum and $1.00-$1.50 for a 55 gallon drum. The other reconditioner does it as a service, i.e., does not pay for the drums. Both firms sell the reconditioned drums for $7.00.

8. Environmental Effects

We were unable to obtain any documentation of incidents caused by disposal of pesticides or containers in the State of New York. State personnel contacted knew of no record keeping or systematic documentation of any incidents on a statewide basis.

V. ECONOMIC ANALYSIS

A. FRAMEWORK OF ANALYSIS

In order to provide a convenient framework for the economic analysis of alternative disposal systems, a general three-level system, shown in Figure 6, can be defined.

The first or source level includes those places, persons and activities which provide or generate used pesticide containers (or excess unused pesticides). Farmers and commercial applicators are part of the source level.

The second level includes the places, persons and activities associated with intermediate handling or storage of the used containers after they leave the source and before they reach the ultimate disposal site. Holding areas and distributors who take back containers from their customers are part of this level.

The third level encompasses the final disposal of the used container or unused pesticide, whether by landfill, incineration or recycle. Containers are transported between these levels, and the possible modes of transport must be defined and analyzed.

Several variations of this general system need to be considered. Most important is the case of on-site disposal, where containers or unused pesticides are disposed of at the source, e.g., at the farm. This system is widely practiced currently, and forms the "base case" against which other alternative systems can be compared.

The second principal variation covers cases where the containers or unused pesticides move directly from the source (farm) to the final disposal site, without passing through an intermediate handling stage. As will be shown, this kind of system is economically attractive only if the final disposal site can be located quite close to the sources.

In the following sections, the economics of alternative actions at each of the three levels are analyzed. Finally, the economics of these parts are assembled into complete systems, and the economic characteristics of each are shown.

The economic characteristics of a complete disposal system depend on the balance between:

- The cost of the disposal or handling operation, and how that cost changes with scale of operation;
- The cost of transporting the containers from one level to another within the system.

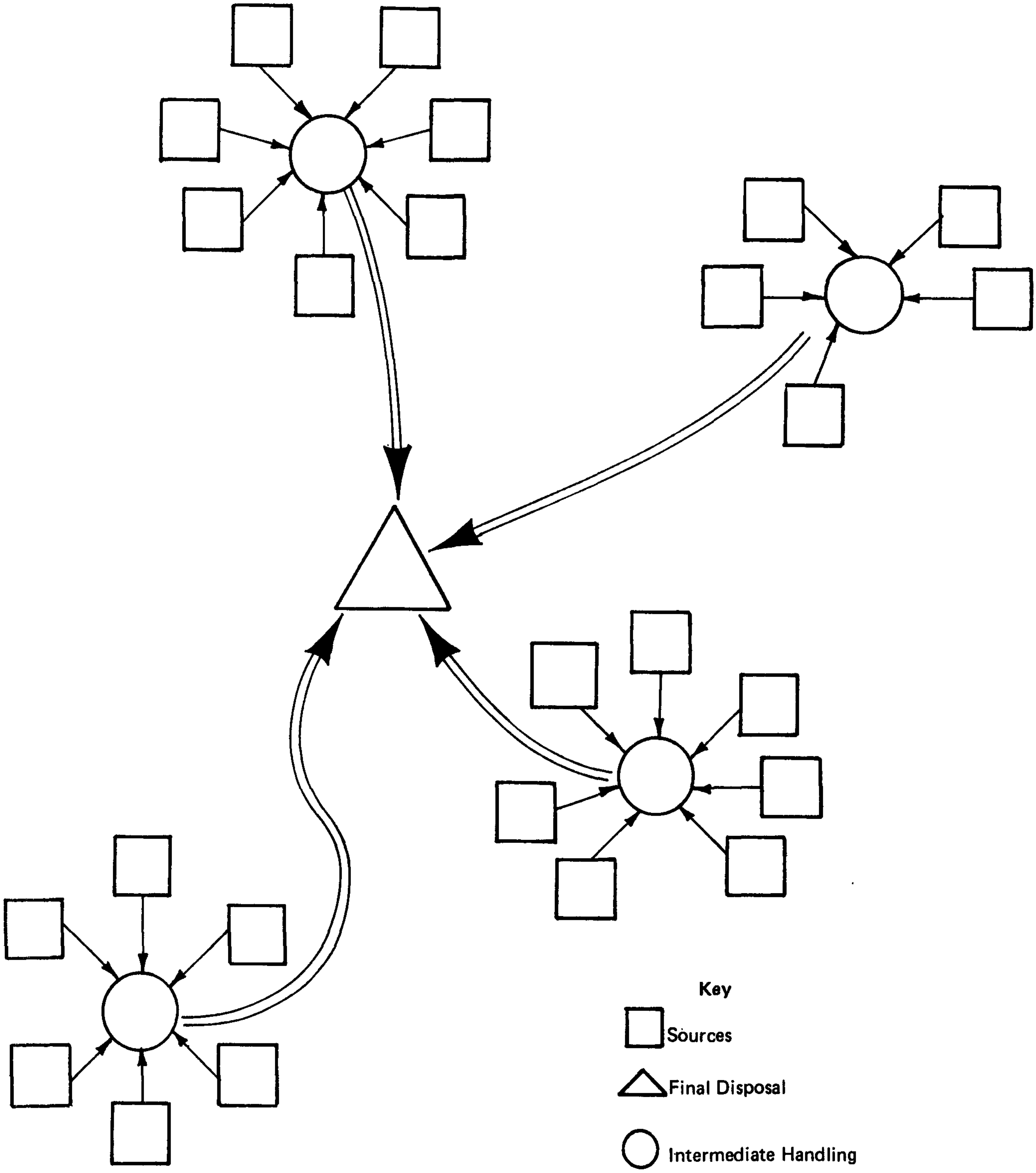


Figure 6. General Three-Level Disposal System

The balance between these costs varies for different systems. The most economical configuration for a system varies significantly between systems. One system may be most economical if disposal takes place at each source site, with no transportation involved. Another system may be most economical if all containers from a multi-state region are transported to one final disposal site. In our analysis, we attempted to identify the most economical configuration of each system considered, so that alternative systems can be compared on the basis of the best that each has to offer.

The economic analysis which follows is based on weight of material handled, and costs are expressed on a unit basis for ease of comparison. To convert numbers of containers to weight, the values shown in Table 40. were used.

Table 40. Container Weights

Size	Weight (lb)
55 gallon	60
30 gallon	46
5 gallon	5
1 gallon	2.4
1/2 gallon	1.8
1 quart	1.3

In computing weights, no distinction is made between metal, glass or plastic containers in the smaller sizes. Material differences are considered in describing disposal technology.

The estimated costs given in the following sections include costs of equipment, labor, raw materials and utilities where appropriate, and in some cases land. While these costs differ from place to place and from time to time, the general nature of the analysis precludes taking these detailed differences into account. We judge that our disposal cost estimates are generally accurate to within +40 percent and -20 percent (i.e., the actual cost is not likely to be more than 40 percent greater than our estimate nor less than 20 percent lower). In most cases we have shown the specific cost estimates for a disposal process in sufficient detail to allow direct determination of the effect of changing one or more item costs on the total cost. The most uncertain elements of the cost factors are indicated, and ranges of disposal costs are provided in several examples. In some examples, the sensitivity of the results to variation in cost factors is also described. Average or "best value" costs are then used in a "systems" analysis which integrates collection and transportation costs with disposal costs for various scales of operation.

B. ON-SITE DISPOSAL

1. Open Dumping

In open dumping, pesticide containers or unused pesticides are combined with other types of solid refuse, generated at the source, in an open area on the user's site. Since the area will exist whether or not pesticide materials are dumped there, the cost of disposing of pesticide materials in an open on-site dump is nil.

2. Controlled Burial

Controlled burial is characterized by burial of the pesticide under two feet of earth in a fenced-in area. The principal costs are associated with digging the hole and subsequent backfilling. The area need not be large and the cost of the fence, amortized over the useful life of the area is negligible.

To bury 10 five-gallon containers in a hole three-feet deep would require excavation of about one cubic yard of material. The cost of this excavation is estimated to be \$4.50, assuming 1.5 man hours at \$3/hr. Backfilling would add another \$1 to the cost. This work could be done much more quickly by machine, but the costs would not likely be lower when the setup time of the machine is considered.

Based on these estimates, the cost of controlled burial would be

$$C = \frac{550}{50} = 11¢/\text{lb or } 55¢/5\text{-gallon container.}$$

This cost is directly proportional to the labor rate, and would be lower if labor is valued at less than \$3/hr. An expected range of disposal costs would be from about 40¢ to 70¢ per 5-gallon container.

3. Open Burning

Empty pesticide bags or cartons are often burned in the open at the site. The principal cost is for labor required to tend the fire. Within the practical limits associated with on-site pesticide bag burning, the duration of the fire probably does not depend significantly on how many bags are burned. Assuming that the fire must be tended for 15 minutes and a labor rate of \$3/hr, the cost of open burning is 75¢. If ten bags are burned, each weighing one pound, the unit cost of disposal is 7.5¢/lb.

C. INTERMEDIATE HOLDING AREAS

A holding area, consisting of a roofed and fenced concrete slab, can be located conveniently to sources so that sufficient containers can be collected at one point to allow efficient, large-scale transport to the final disposal site. The area might be located adjacent to a pesticide distributor's facility or at the local landfill site.

Assuming that containers are piled six feet high and that the density of uncrushed containers is 167 lb/cubic yard (based upon data from California landfill operations), a holding area of 300 sq yds is required to hold 100,000 lbs of containers.

The size of the holding area actually built will depend, of course, on the size of the area that it serves, how often it is open and how frequently the stored containers are removed to the disposal site. Minimum capacity is one large truckload (60 cubic yards, which could handle 2000 five-gallon containers which weigh 10,000 lbs). Unit costs are essentially independent of size. The cost of operating such an area is essentially equal to the amortized capital cost of the facility. No utilities are required, and the only labor needed is to open and close the facility at the appropriate times.

The capital cost of a 300 sq yd area is estimated to be \$32,000, based on concrete at \$2/sq ft and roofing at \$10/sq ft including labor. If the capital is amortized over ten years, and the turnover time in the area is three months, the unit cost of operating the holding area is:

$$C = \frac{3,200,000}{(100,000)(4)(10)} = 0.8¢/\text{lb}.$$

This cost will be relatively insensitive to the size of the holding area since the capital costs are essentially proportional to size. More rapid turnover would allow more containers to be handled in a given facility, so that cleaning out the area more than four times per year would reduce the unit cost proportionately below 0.8¢/lb. An anticipated range would be from about 0.7¢/lb to 1.2¢/lb depending upon construction costs and turnover rates.

D. FINAL DISPOSAL

In estimating the costs of the alternative methods of disposal of pesticide containers and unused pesticides, an important question is, "at what scale of operation should the costs be estimated?" Unit operating costs generally decrease as the amount of material handled increases, so that the choice of scale affects the estimated cost.

For each process considered, we have selected a scale of operation which is on the low side of the scale appropriate for the particular process. Alternative processes can only be compared at comparable scales of operation. Later, each process will be scaled according to general engineering rules, so that a direct comparison of systems costs can be made.

1. Landfill

Burial of pesticide containers in specially designated landfills is practiced in California, and some cost data are available. As indicated in Section IV-C, a typical class I landfill is open for two 10-day periods each year. During these periods, it is manned by three men equipped with special protective gear. A bulldozer is used to crush and cover the containers.

We will assume that containers brought to the landfill have been properly rinsed by the user. If the landfill is properly sited and engineered to contain hazardous materials, unrinsed containers could be landfilled directly with no danger. On-site rinsing at the landfill poses the problem of rinse-water disposal and could be expensive. Rinsing might be accomplished in as little as one minute per can using a specially designed rinsing sprayer, but this operation could add 10¢ per container (or 2¢ per pound for a five-gallon container) to the costs estimated below. In addition, rinsing would complicate the intake procedure.

The estimated daily operating cost (of the California landfill), assuming a labor rate with overhead of \$6/hr and a bulldozer rental cost of \$10/hr, is \$224/operating day. Depreciation of the capital cost of the landfill amounts to \$300/yr or \$15/operating day. The yearly intake of containers was estimated to be 15,000 cubic yards at a density of 167 lb/cubic yard, or 1250 tons/year. The unit cost is therefore

$$C = \frac{(239)(20)}{1250} = \$3.83/\text{ton or } 0.19¢/\text{lb or } 0.95¢/5\text{-gallon container}$$

This cost is low relative to what might be encountered in other areas. The low depreciation cost is due to inexpensive land (\$100/acre) and the need for only minor site preparation. In other locations, higher costs for these factors could increase the amortization cost by a factor of ten to \$3000/yr or \$150/operating day.

In addition, adequate cover material was available at the California site. As much as 200 cubic yards of cover material could be required per day, depending on the topography of the landfill, to cover the 750 cubic yard daily intake of containers to a depth of two feet. Acquisition of this fill from another site could add another \$200-\$300 to the daily cost. Under these circumstances, the unit landfill cost ranges from

$$C = \frac{(574)(20)}{1250} = \$9.20/\text{ton or } 0.46¢/\text{lb or } 2.3¢/5\text{-gallon container}$$

to

$$C = \frac{(674)(20)}{1250} = \$10.78/\text{ton or } 0.54¢/\text{lb or } 2.7¢/5\text{-gallon container.}$$

Recognizing the variability of the costs due to site characteristics, we estimate the unit cost of disposal of pesticide containers in special landfill to be in the range of about \$4 to \$11 per ton (0.20 to 0.55¢/lb).

Containers and unused pesticides can be collected and landfilled with other types of solid waste. The unit landfill costs associated with this scheme are governed by the amount of other waste handled at the landfill and cannot be separately estimated from information on pesticide containers alone. We expect that the unit costs would be less than those in the special landfill described above, and might be expected to fall in the range of \$2 to \$4 per ton.

2. Encapsulation and Burial

Pesticide containers and some pesticides can be rendered less susceptible to leaching in a landfill by encapsulation of the materials in asphalt or concrete prior to burial. The encapsulation process is shown in Figure 7. Containers are first crushed and then mixed with asphalt in a steam-heated vessel. The mixture is put in 55-gallon drums which are covered and buried.

For a process disposing of 2000 lb of material per day in a mixture containing four volumes of asphalt to one volume of material, the costs are estimated as follows.

Installed capital cost $32,000

Operating Cost	$/day
Raw materials--asphalt 1000 lb @ 1¢/lb	10
--drums 2 @ $5	10
Steam 10,000 lb @ $2/1000 lb	20
Labor - 8 man-hr @ $6/hr	48
Overhead	24
Depreciation, Maint. and Ins.*	36
	$148
Burial:	
Excavation 2 CY @ $5/CY	10
Backfill and Cover	5
	15
TOTAL COST	$163/day

* Depreciation, maintenance and insurance are taken to be 20%, 5% and 2%, respectively of the installed capital cost.

Unit cost $C = \frac{16300}{2000} = 8.2$¢/lb (or 41¢/5-gallon container) at a capacity of 480,000 lb/yr.

Concrete could be used as the encapsulating material with no appreciable change in cost.

The greatest uncertainty is in the labor effort and rate and the capital costs of the operation. As indicated earlier, we believe our estimates to be accurate to within -20% to +40%. Thus the unit cost of encapsulation and burial of the 5-gallon container should be in the range of 33¢ to 57¢ per container.

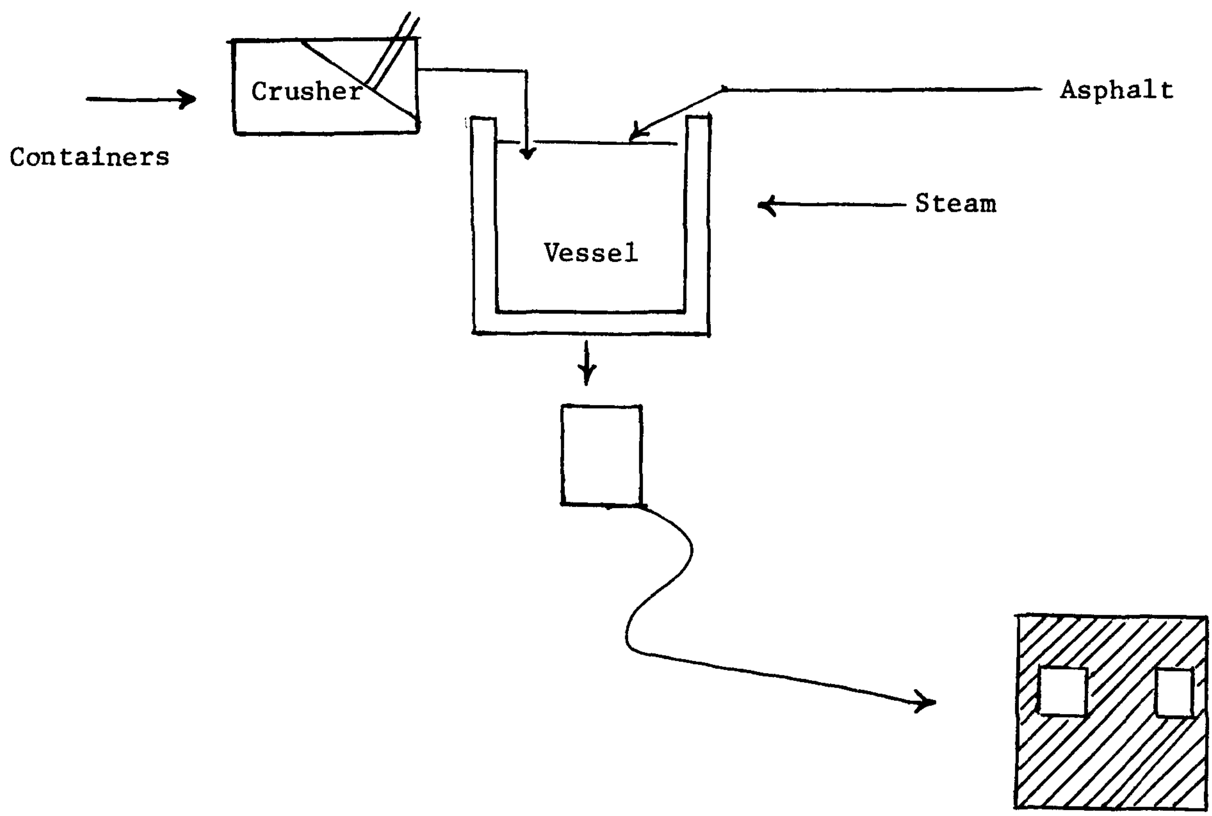


Figure 7. Encapsulation Process

3. Incineration

Metal containers can be decontaminated by exposing the shredded containers to high temperatures (around 2000°F) in an incinerator. The stack gases must be scrubbed to remove potential pollutants arising from the combustion of the residual pesticide. Figure 8 shows a diagram of the system. The estimated costs for a system designed to process 700 five-gallon containers per hour, or 28,000 lb of containers/day are, as follows.

Capital Cost $300,000

Operating Cost	$/day
Fuel--35 MM Btu/day at $1.50/MM Btu	53
Labor - 16 man-hrs @ $6/hr	96
Overhead	48
Depreciation, Maintenance and Insurance	337
	$534/day

Unit cost = $\frac{53,400}{28,000}$ = 1.9¢/lb (or 9.5¢/5-gallon container) at a capacity of 6,700,000 lb/year. Again, the greatest uncertainty is in the labor and capital costs, and assuring environmental control.

The scrap metal from the incinerator might be sold for scrap, depending on the local market conditions. A scrap price of $20 per ton would reduce the unit costs by 1¢/lb. If the metal cannot be sold, it can be landfilled for a cost of around 0.2¢/lb. Glass residue would also be landfilled.

Pesticides, either solid or liquid, and plastic containers can be incinerated in a kiln, equipped with a spray chamber to cool the exhaust gases, and a scrubber to remove harmful combustion products such as HCl. Figure 9 shows such a system. Operating costs are estimated as follows:

Capital Cost $1,000,000

Operating Cost	$/day
Fuel oil 4320 gal/day @ $0.20/gal	864
Cooling water L7 x10^6 gal/day @ 0.05/1000 gal	85
Lime hydrate 50,000 lb/day @ 0.012/lb	600
Power 8400 kw-hr @ 0.015/kwhr	126
Labor 32 man-hrs @ $6/hr	192
Overhead	96
Depreciation, Maintenance & Insurance	1125
	$3088

Unit cost = $\frac{308,800}{21,000}$ = 14.7¢/lb at a capacity of $5,000,000 lb/yr.

The costs of testing and analysis and assuring environmental control for such a facility could increase these costs by 50%, giving a cost range of about 15 to 25¢/lb. Note also the relatively high capacity of the facility.

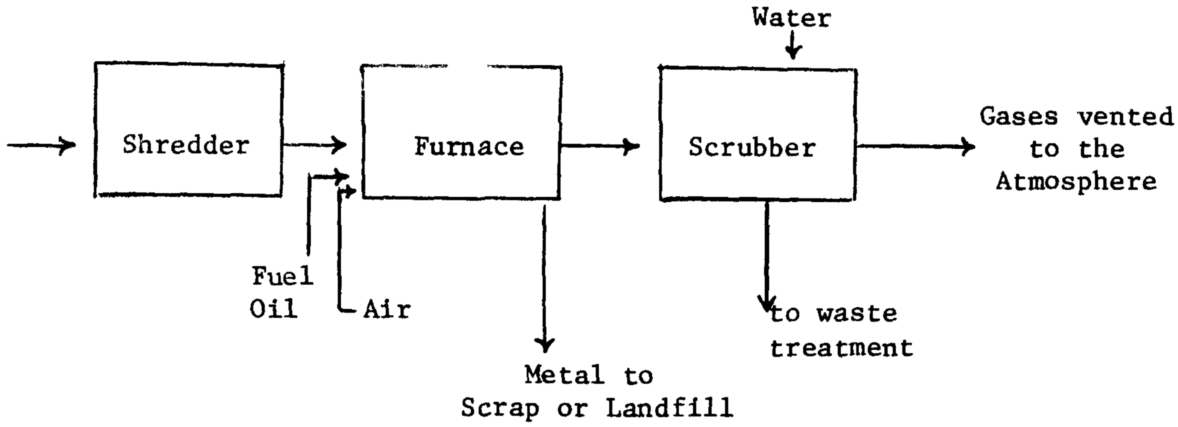


Figure 8. Incinerator for Pesticide Containers

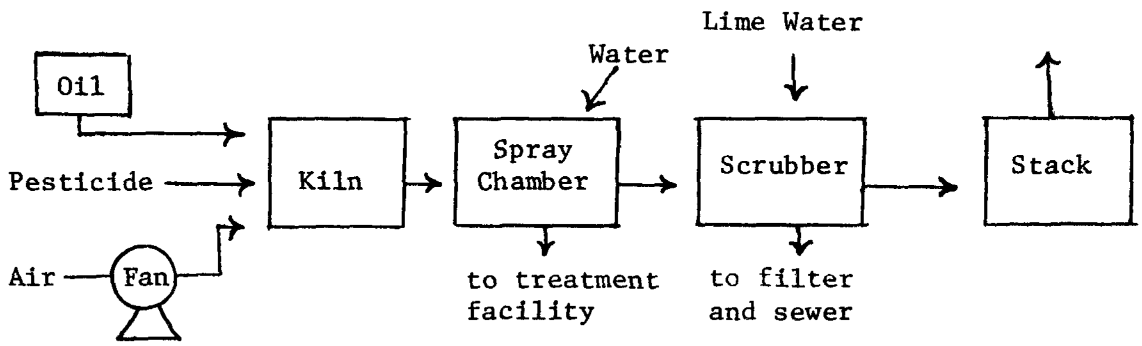


Figure 9. Incinerator for Unused Pesticides

Unit costs of incinerating pesticides are much higher than those for pesticide containers since there is more combustible matter per pound fed. Hence a larger furnace and scrubber are required. If an "empty" 5-gallon container weighing 5 lb contains 4 oz of residual pesticide, only one-twentieth of the weight fed must be burned in container incineration, as opposed to total combustion when pesticides are incinerated.

4. Reuse/Recycle

a. Reclamation of Large Containers for Reuse

Economic data on reclamation of 55- and 30-gallon containers for general reuse was given in Section IV-C.

b. Recycle of Small Containers

Small metal containers can be recycled as scrap. Figure 10 shows a process in which the containers are shredded to expose maximum surface area, and washed in a detergent or mild caustic solution. The entire system, shredder, storage hopper and washer are maintained under a slight negative pressure to prevent leakage of fumes into the operating area. The in-leakage of air is collected and scrubbed with a mild caustic solution to remove traces of pesticide vapor before the air is exhausted to the atmosphere. The cost of a system to process 4000 lbs of containers per day is estimated as follows.

Capital Cost $30,000

Operating Cost	$/day
Hot water 5000 gal @ 50¢/1000 gal	3
Labor 8 man-hr @ $6/hr	48
Overhead	24
Depreciation and Maintenance	34
	$109/day

Unit cost = $\frac{10900}{4000}$ = 2.7¢/lb (or 13.5¢/5-gallon container) at a capacity of 960,000 lb/yr. A scrap price of $20 per ton would reduce the unit cost to about 1.7¢/lb, if the scrap could be readily sold.

E. TRANSPORTATION OF CONTAINERS AND PESTICIDES

1. Source Level to Intermediate Level

Two methods of transporting containers from the source to a holding area (or final disposal site) were considered: delivery by the individual user, and organized collection.

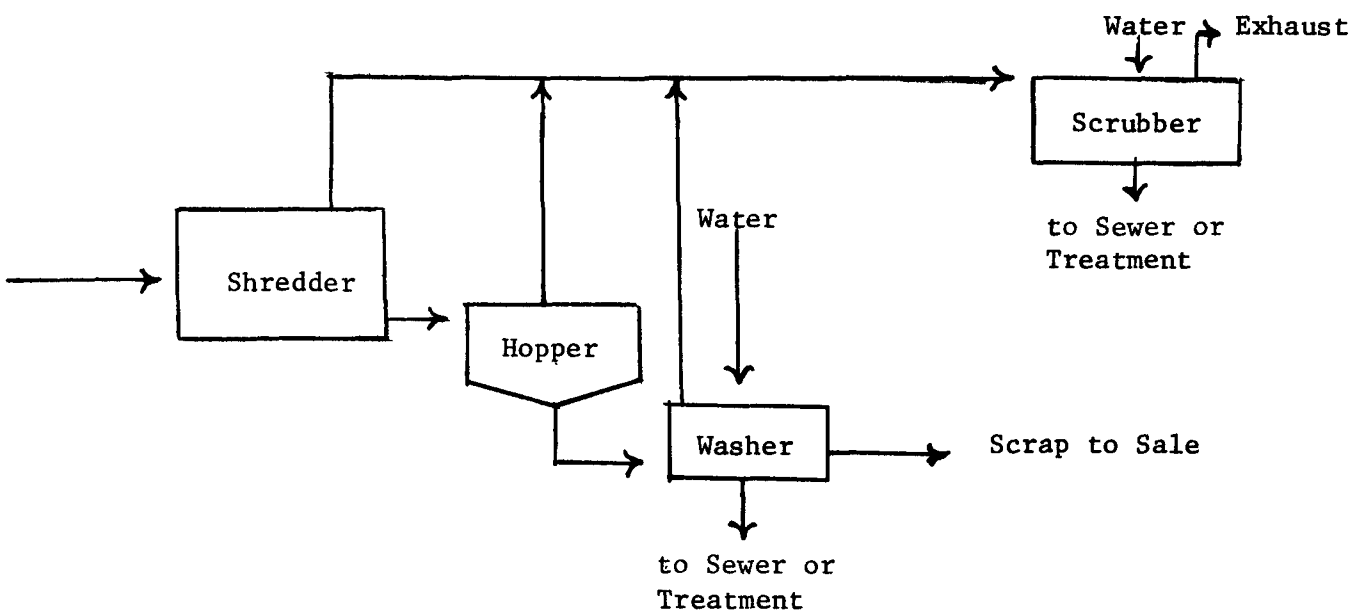


Figure 10. Scrapping of Small Metal Containers

The cost of delivery by the individual user depends on how far he must take them (M miles), how much he takes at a time (N lbs of containers or pesticides) and how much his time is worth (L \$/hr). Assuming that the out-of-pocket cost of vehicle operation is 10¢/mile and that an average speed of 30 miles per hour can be maintained, the cost per pound delivered is:

$$C = [0.10 + \frac{L}{30}] \frac{2M}{W} \text{ (\$/lb)}$$

If

L = \$2/hr
M = 10 miles
W = 50 lb (10 five-gallon containers)
C = 6.7¢/lb or 33.5¢/5-gallon container.

The cost is high and perhaps unrealistic. Lower labor costs, shorter distances and larger loads reduce the cost. Also, for example, if the holding area is on the way to a location that the user normally visits, the cost of the trip attributable to delivery of the containers may be nothing. In summary, then, the cost of user delivery can range from nothing to around 7¢/lb, (for a ten-mile trip) depending on the circumstances. This uncertainty will be important in assessing the overall costs of disposal systems, since the costs of operation per pound at other system levels can be considerably less than 7¢/lb.

An alternative to individual user delivery is organized periodic collection of containers from a number of sources. This collection service could be contracted to a local trucker as required. The time required per pound of material collected depends on the distance between stops (M miles), the weight of material collected at each stop (W lb/stop) and the time spent in talking to the user, locating the material and loading it onto the truck (t hours/stop). Assuming an average over-the-road speed of 30 mph, the time per pound is:

$$(\frac{M}{30} + \frac{t}{60}) \frac{1}{W} \text{ (hrs/lb)}$$

The cost of truck and driver is estimated as follows:

Capital cost of truck \$15,000
Depreciation period 5 years
at 1872 hrs/yr
Operating and Maintenance Cost \$1.50/hr
Drivers wages \$6.00/hr

Therefore, the hourly cost is:

Depreciation	\$1.60
Operation and Maintenance	1.50
Labor	6.00
	\$9.10/hr

and the unit cost of collection is:

$$C = (9.10)\ (\frac{M}{30} + \frac{t}{60})\ \frac{1}{W}\ (\$/lb)$$

If

M = 1 mile
t = 10 minutes
W = 50 lb (10 five-gallon cans)
C = 3.6¢/lb or 18¢/5-gallon can.

This collection cost is significantly lower than the "upper limit" for user delivery of 7¢/lb computed earlier, and about equal to the user delivery cost if the user's time is free.

In addition, the collected load of 2000 lb must be delivered to a holding area or final disposal site. If the site is M miles from where the collection day ends, the transport cost is

$$C = (910)\ (\frac{2M}{30})\ (\frac{1}{2000})$$

$$= 0.03M\ ¢/lb$$

If the holding area is 20 miles away, the transport cost of 0.6¢/lb must be added to the collection cost of 3.6¢/lb.

2. Intermediate Level to Final Disposal

When containers are collected at a holding area or distributor, they can be transported to the final disposal site in large quantity in a tractor-trailer rig with considerable saving in unit cost. This cost can be estimated using the equations developed for collection costs given above. For this application, the loading time will probably be insignificant relative to the on-the-road time. Taking the capital cost of the tractor-trailer to be $40,000, the hourly depreciation cost based on 5-years operation is $4.30/hour, and the total cost is:

Depreciation	$ 4.30
Operation and Maintenance	2.40
Labor	6.00
	$12.70

Using a density of uncrushed containers of 167 lb/cubic yard, a 60-cubic yard trailer will carry 5 tons, or 10,000 lb. Therefore, the unit cost of transport is

$$C = (1280)\ (\frac{2M}{30})\ (\frac{1}{10,000})\ (¢/lb)$$

where M is the distance to the disposal site, and it is assumed that the cost of the return trip must be charged against container transport.

If the distance from holding area to final disposal site is 100 miles, the unit transport cost is about 0.9¢/lb.

The unit cost per unit distance (C/M), which will be useful in the system analysis is 0.009¢/lb-mile. Actual unit transport costs are obtained by multiplying this value by the one-way distance to the disposal site.

F. SUMMARY OF SYSTEM COSTS

1. Economic Justification of Holding Areas

In transporting the containers or pesticides to the ultimate disposal site, the user (or collector) may take them directly to the final site or he may take them to a holding area where they are stored and later trans-shipped to the final disposal site (see Figure 6).

To compare these alternatives, we will assume that the final disposal site is D miles away from the sources, on the average, and that a holding area is H miles from the sources. If the sources are uniformly distributed around the holding area, the distance from holding area to disposal site is also D miles.

As shown earlier, the cost of direct transport to the disposal site by the user ranges from nil to 0.67¢/lb-mile. Taking the higher figure, the per pound cost is

$$C_1 = 0.67\ D\ (¢/lb)$$

The cost of using the holding area has several components; the cost of user delivery to the holding area (0.67 H ¢/lb), the cost of operating the holding area (0.8¢/lb) and the cost of trans-shipping to the disposal site (0.009 D ¢/lb). The total cost is:

$$C_2 = 0.67\ H + 0.8 + 0.009D$$

Holding areas are preferable if C_2 is less than C_1. This inequality implies that use of holding areas are preferable to direct transport if:

D is more than (H + 1.2) miles.

This shows that users can only afford to drive an extra 1.2 miles to get to a disposal area in order to save the cost of a holding area. The uncertainty in the user's delivery cost must again be emphasized. If the disposal site is on the way to a location the user visits anyway, the delivery cost is nil and direct transport to the disposal site is preferable no matter how far away it is.

A similar analysis can be made in which user delivery is replaced by collection truck delivery. Since the cost of delivery by collection truck is 0.03¢/lb-mile, direct delivery to the disposal site is preferable if:

D is less than 1.5 H + 40 miles.

Because of the lower per mile cost of truck delivery, direct transport is more often attractive. The table below shows the values derived from the basic inequality.

If H Will Be	then	Go direct to disposal if D is less than
5 miles		47.5 miles
10		55
20		70
30		85

For example, holding areas built so that the average user was 20 miles away (H = 20 miles) would be economical if the disposal site was more than 70 miles away (D = 70 miles) from the average user.

This analysis is based on the assumptions of uniform rates of generation of pesticide containers and no restriction on the location of the holding area. In practice, areas would be sited to reflect local container use patterns at available and convenient locations.

In summary, conveniently located holding areas are economically justified in nearly all cases where the user delivers the pesticide containers or unused pesticide. If source-to-source collection is provided as part of the disposal system, there is less economic incentive for closely spaced holding areas.

In the analysis of disposal alternatives that follows, we will assume that holding areas are included as part of the disposal system. Transport of containers and unused pesticides to the final disposal site will be by large truck.

2. Final Disposal Alternatives

The economics of final disposal and the economics of transportation presented earlier can be combined to show the best scale of operation for each of the disposal alternatives. The most economical system for each alternative can then be compared.

The unit cost of transporting material to a central site and processing it there can be expressed as:

$$C = \underbrace{C_T D}_{\text{Trans- portation Cost}} + \underbrace{C_o \left(\frac{L}{L_o}\right)^{-n}}_{\text{Processing Cost}}$$

where

C_T is the transport cost per pound-mile

D is the one-way transport distance from holding area to disposal site

C_o is the unit processing cost (¢/lb) at the base capacity of L_o (lb/day)

L is the actual capacity of the facility (lb/day)

n is an empirical exponent used to scale cost estimates from one capacity to another.

While processing costs associated with different processes will scale somewhat differently (i.e., have different values of the empirical exponent n), the value of n for most processes lies in the range of 0.4 to 0.6. We have chosen the value of 0.6 for this analysis, since the processes we are dealing with tend to be labor intensive and therefore more strongly variable with capacity. Recognizing the uncertainties inherent in our knowledge of how many pesticide containers may be generated in a specific area, more precise analysis is not warranted at this time. The value of n chosen, within the limits stated, will not have an important effect on the nature of the results obtained.

The basic solution considered is shown in Figure 11. Pesticide containers are assumed uniformly distributed over the area. These containers are brought to the final disposal site in large trucks. The capacity of the disposal facility (L) is related to the size of the area served by

$$L = \pi R^2 \rho$$

where

ρ is the density of container generation (lb/sq mi-day)

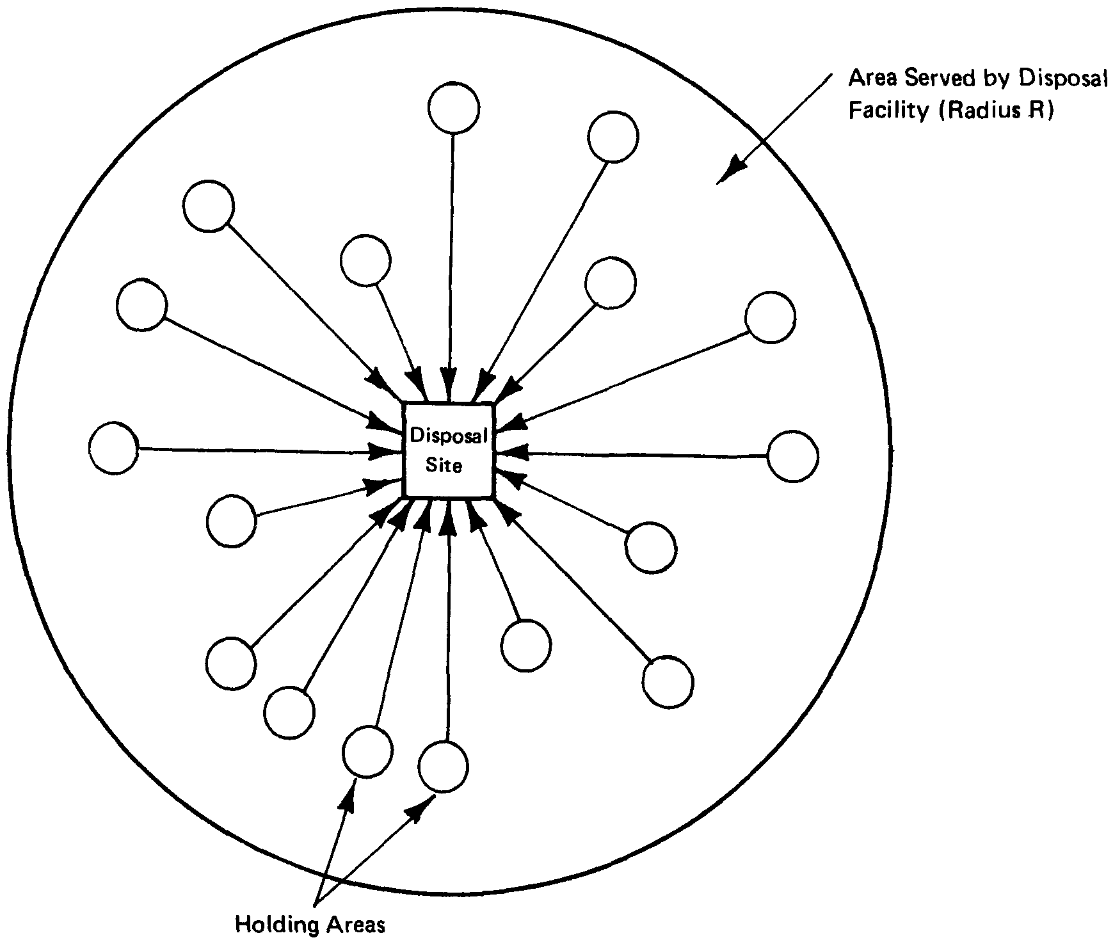


Figure 11. General Disposal System

The average transport distance to the disposal site is (2/3) R. The unit cost can then be expressed in terms of R, the radius of the area served by the disposal facility, and ρ, the density of container generation.

$$C = \frac{2C_T R}{3} + C_o \left(\frac{\pi R^2 \rho}{L_o}\right)^{-n}$$

The other factors, C_T, C_o and L_o are parameters known from the cost estimates made in preceding sections.

For each disposal alternative considered, the cost (C) can be calculated and arrayed as a function of R and ρ. Figure 12 shows the relationship for disposal by encapsulation and burial. The unit cost increases with decreasing density, since a larger area must be served to accumulate a given amount of material. For any given density, there is a minimum unit cost at the radius at which the increase in transport cost with increasing distance just balances the reduction in processing cost with increasing capacity.

For encapsulation and burial, costs range from as high as 25¢/lb, for small plants serving areas with low container density, to as low as about 2¢/lb for larger plants serving high generation rate areas. The radius of service which gives the lowest cost is about 200 miles at a density of 100 lb/sq-mi-year (20 five-gallon containers/sq mi-year). This optimum radius rises with decreasing density to a value of about 400 miles at a density of 10 lb/sq mi-year.

The range of densities covered is based on container generation data from California and Mississippi (Section IV). If all containers are included, densities range as high as 200 lb/sq-mi-yr in Mississippi and 140 lb/sq-mi-yr in California. If only the smaller containers (5-gallon and smaller) are considered for disposal, the densities are 65 and 36 lb/sq-mile-yr respectively. In states where agriculture is less intense, generation densities as low as 10 lb/sq mile-yr might be found.

Figures 13 and 14 show the same information for container incinerators and recycle by scrapping, respectively. These processes show essentially the same pattern as does encapsulation and burial. Costs are very high for small plants serving low density areas. For larger plants, serving areas of radius 150 miles or more, costs drop into the range of 1.5 to 5¢/lb, depending on container density.

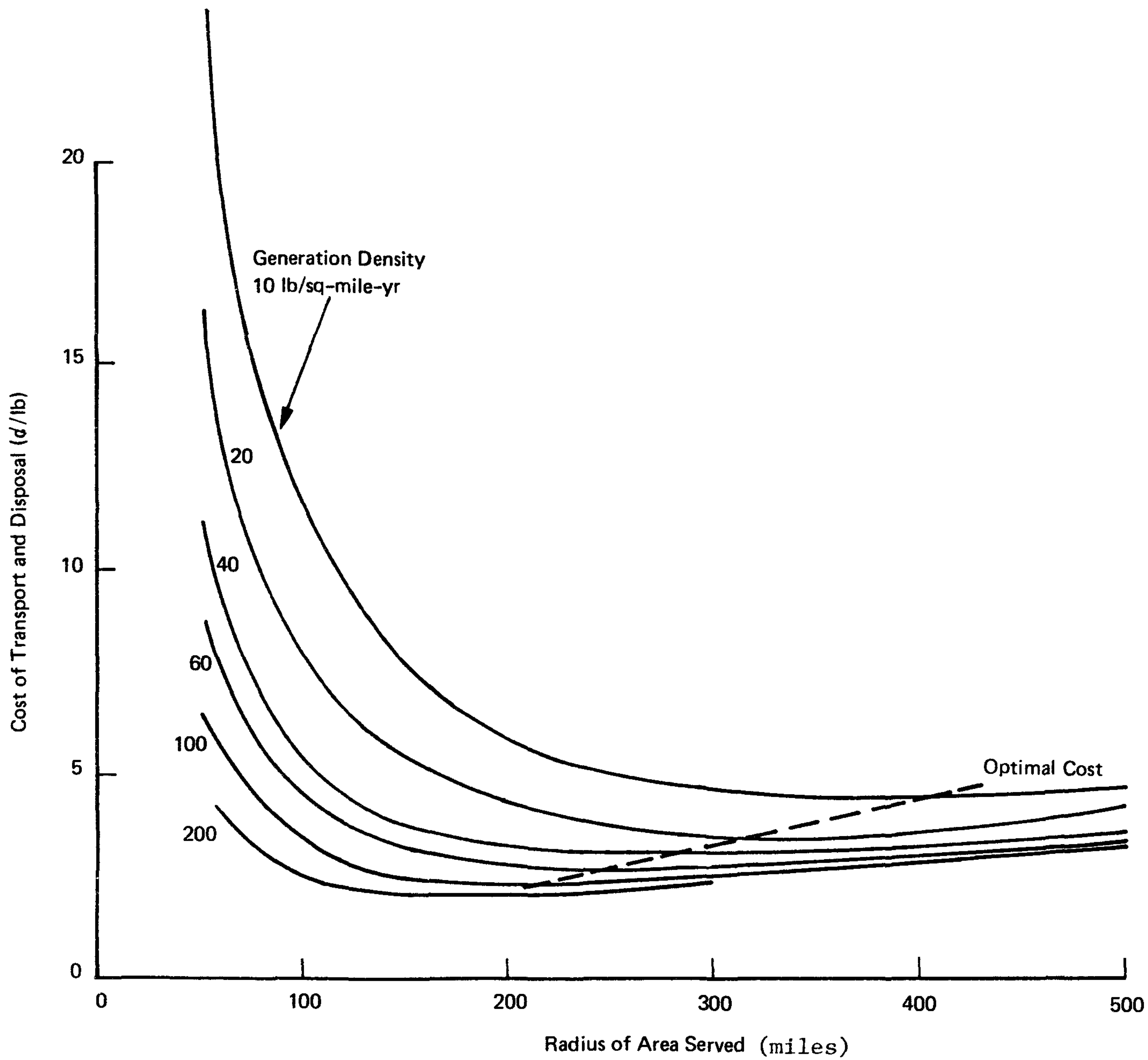


Figure 12. Costs of Encapsulation and Burial

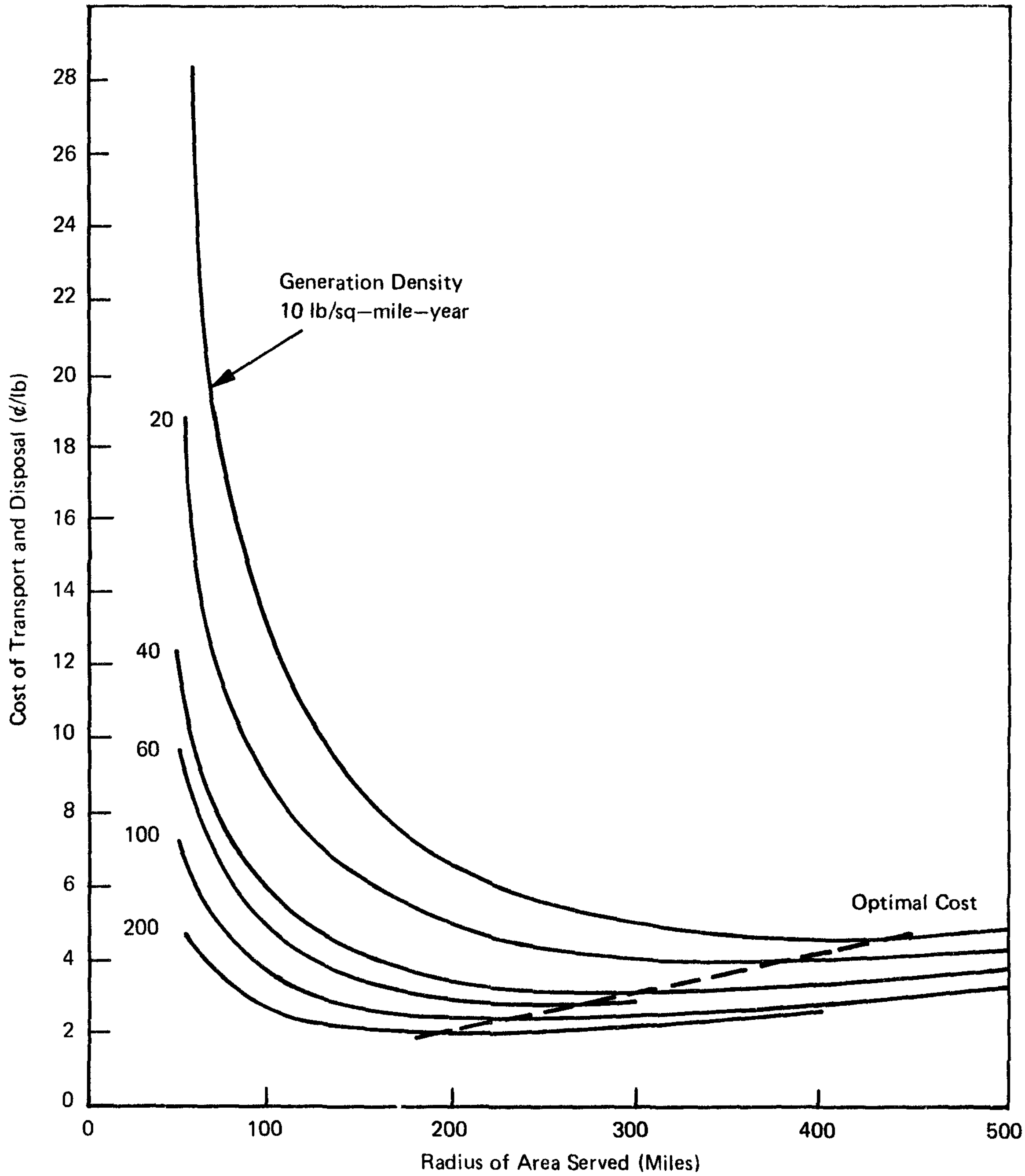


Figure 13. Costs of Container Incineration

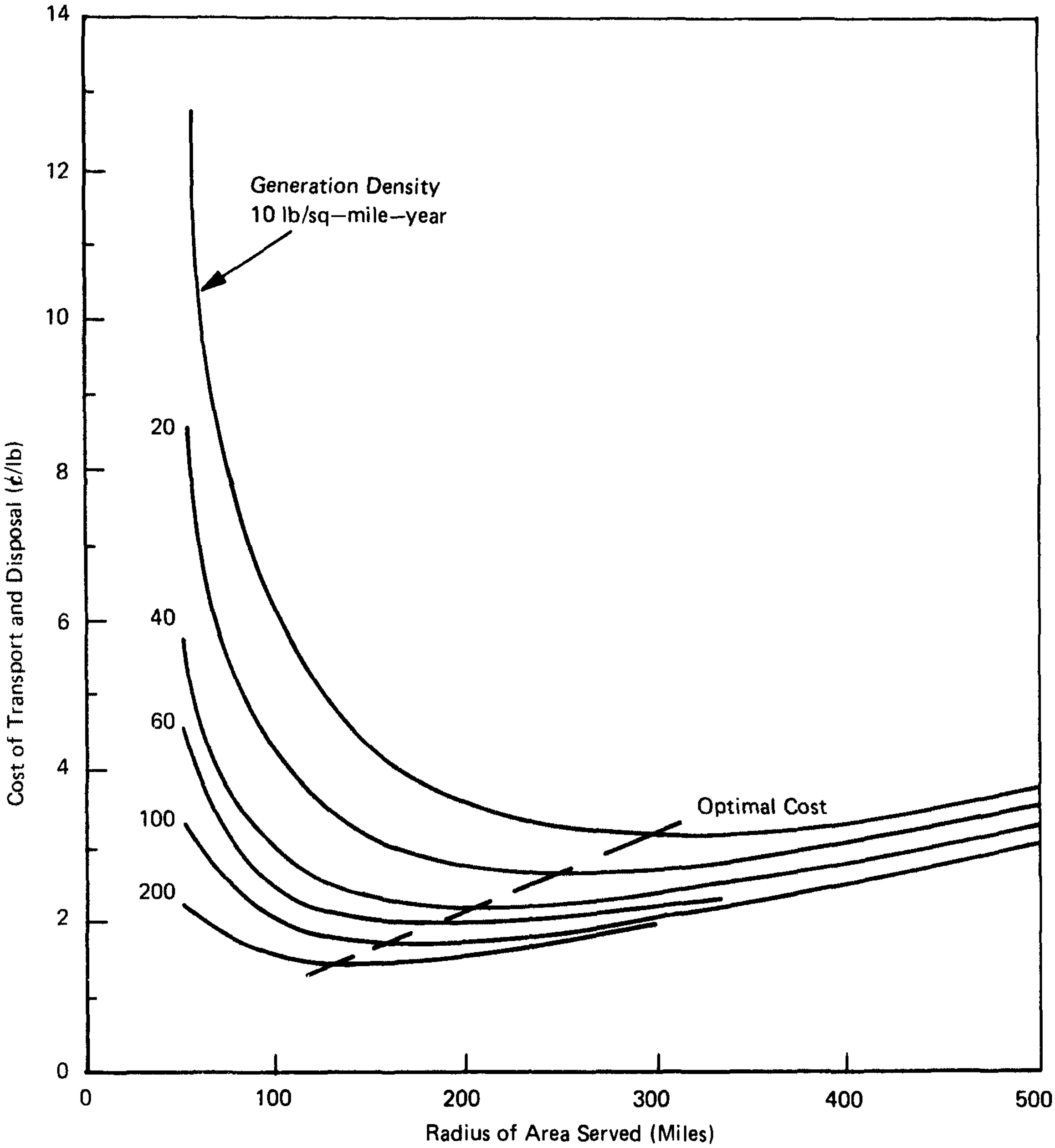


Figure 14. Costs of Recycle by Scrapping

For both container incineration and recycle by scrapping, processing costs can be at least partially offset by revenues from the sale of scrap. A scrap price of \$20 per ton (1¢/lb) would reduce the net cost of the optimally sized recycling process to about 1¢/lb. Scrap prices this high and higher have been available in recent years, but the scrap market is volatile and the level of anticipated revenues from sale of scrap cannot be predicted with confidence.

Figure 15 shows the system costs for sanitary landfill. The optimally sized landfill serves an area 70 to 150 miles in radius, at costs ranging from about 0.8 to 1.8¢/lb. This system differs from the others discussed above in that costs for facilities much smaller than the optimum do not rise nearly as much. For example, the cost of a landfill system serving a 50-mile radius with a container density of 10 lb/sq mile-yr can be operated for about 3.5¢/lb, compared to costs of 13 to 30¢/lb for the other systems.

The costs computed in this analysis are based on the assumption that the facilities handle pesticide containers or pesticides alone. If other wastes are processed at the same facility as they normally would be, unit costs will be somewhat lower than those shown. However, the general pattern of cost, depending on area served and density, will still apply.

Large containers (55- and 30-gallon drums) are routinely reconditioned in California. Cost data from California reconditioners can be used to estimate the condition under which reconditioning would be economically feasible in other areas. Since drums other than pesticide containers are reconditioned routinely by private companies, and the number of pesticide drums to be handled is probably a small fraction of the total, the cost of pesticide drum reconditioning does not depend on how many are so processed.

Representative costs associated with 55-gallon drums are:

Payment to user for drum (P)	\$0.50-1.00
Reconditioning Cost (r)	\$3.25
Value of reconditioned drum (v)	\$6.00-9.00

The other component of cost is that associated with transporting the drums from a holding area near the user to the reconditioning facility. Assuming that the drums are transported in a 60 cubic yard truck (carrying about 170, 55-gallon containers), the transport cost is about 0.2¢/ container mile.

If the holding area is M miles from the reconditioning plant and the truck travels empty one way, the total cost of drum reconditioning is

$$\text{Cost} = P + r + \left(\frac{0.2}{100}\right)(2M)$$

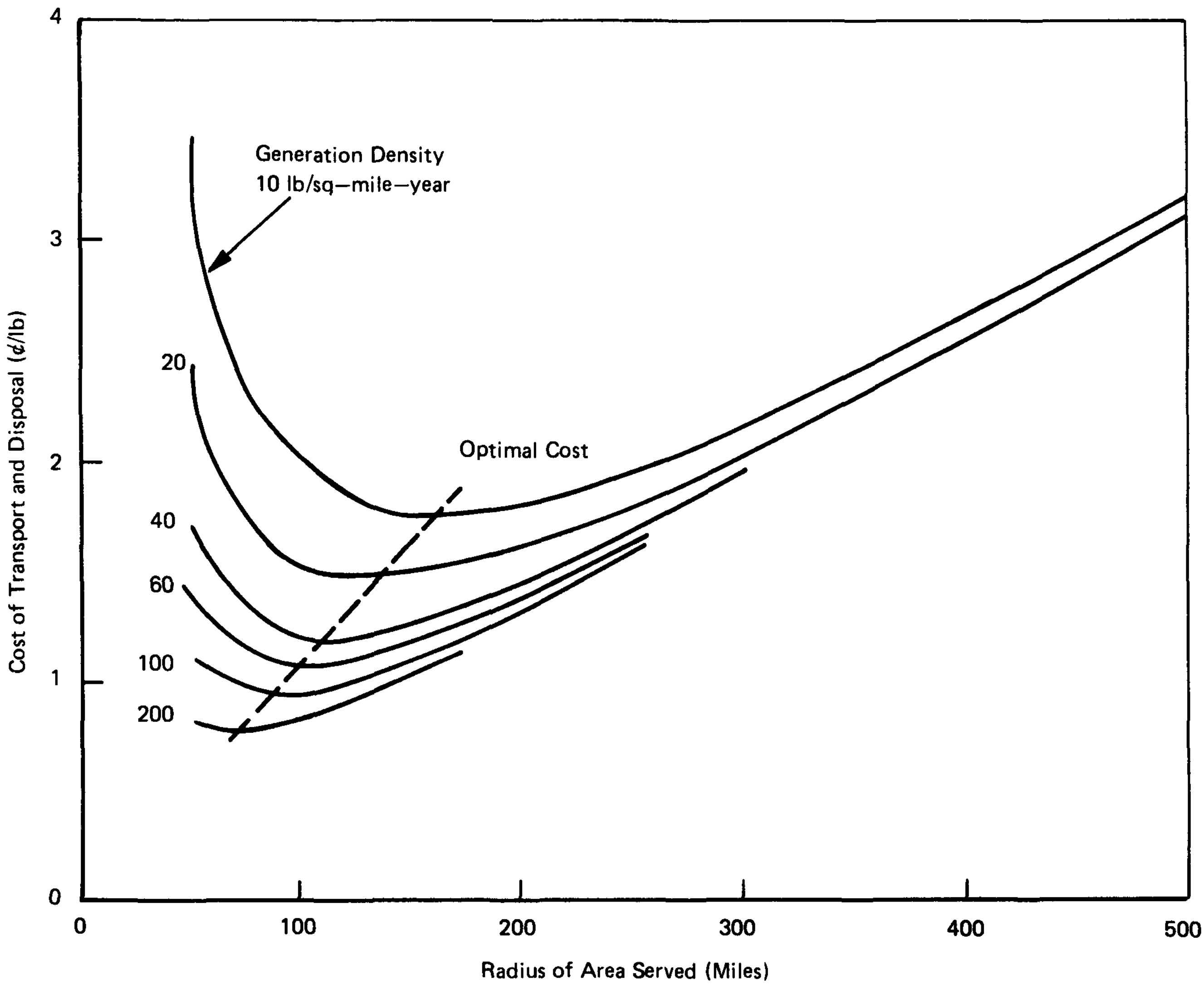


Figure 15. Costs of Sanitary Landfill

and the revenue from sale of the drum is v. Equating the cost and the revenue and solving for M yields

$$M_o = \frac{(v - P - r)}{0.004}$$

If the transport distance from holding area to reconditioning facility is less than M_o, the reconditioning is profitable.

Taking the most conservative values for costs and revenue from the data obtained in California yields

$$M_o = \frac{6.00 - 1.00 - 3.25}{0.004} = 440 \text{ miles}$$

Taking the most liberal cost and revenue values yields

$$M_o = (9.00 - 0.50 - 3.25)/(0.004) = 1310 \text{ miles}$$

It is likely that nearly every agricultural area is within 450 miles of a private drum reconditioner, so that reconditioning appears to be a generally valid and economical method for handling large used pesticide containers.

Drum reconditioners interviewed were generally skeptical of the validity of reconditioning and reusing smaller pesticide containers (5-gallon and smaller), except as they can be directly reused by the pesticide formulator. They believe that these containers are too fragile for effective reconditioning and that the reconditioning cost would exceed the value of new containers. The price of new 5-gallon containers is currently quoted at about $1400 per thousand ($1.40 each) FOB the factory.

Those containers which are damaged in use and cannot be reconditioned can be disposed of with the smaller containers. Only a small fraction of the large containers should fall into this category.

3. Some Specific Examples

The general analysis described in the proceding section was based on a uniform container generation density with each disposal facility serving a circular area around it. The equations on which the analysis is based can also be used to estimate the costs of alternative systems under more realistic conditions.

These estimates are intended only to provide guidance as the range of costs to be expected and the relative effects on those costs of disposal technology and container generation density. More detailed engineering designs, taking into account the specific characteristics of the local areas served, would be required for more detailed cost estimates.

Table 41 shows the number and estimated weight of containers generated in the state of California in 1969 (Rogers and Cornelius, 1970).

Table 41

Annual Container Generation in California (1969)

	No.	Estimated Wt Per Container (lb)	Total Wt (lb)
55-gallon	8,000	60	480,000
30-gallon	98,000	46	4,508,000
small metal	346,000	5	1,730,000
small glass and plastic	172,000	1.8	310,000
Subtotal	624,000		7,028,000
Paper sacks	3,239,000	0.5	1,620,000
Other paper	8,000		---
Total	3,871,000		8,648,000

The use of pesticides is concentrated in three principal areas in California (see Figure 16);

- An area in Central California encompassing the San Joaquin Valley and about 430 miles by 100 miles in dimension (43,000 sq miles)
- An area southwest of Los Angeles measuring about 50 by 50 miles (2500 sq miles)
- The Imperial Valley in southern California, measuring about 50 by 50 miles (2500 sq miles)

Taking first the incineration systems for containers and assuming that only metal containers are processed, Table 41 shows an annual generation rate of 6,718,000 lbs per year. If only the small metal containers (5-gallon) are processed, the comparable figure is 1,730,000 lb/year.

Assuming a uniform generation rate in each of the three agricultural areas, the generation density ranges from 36 to 140 lb/sq mile-year.

For each of these generation densities, the system costs for incineration were estimated for the following service areas:

A - One incinerator serving the San Joaquin Valley
B - Two incinerators serving the San Joaquin Valley

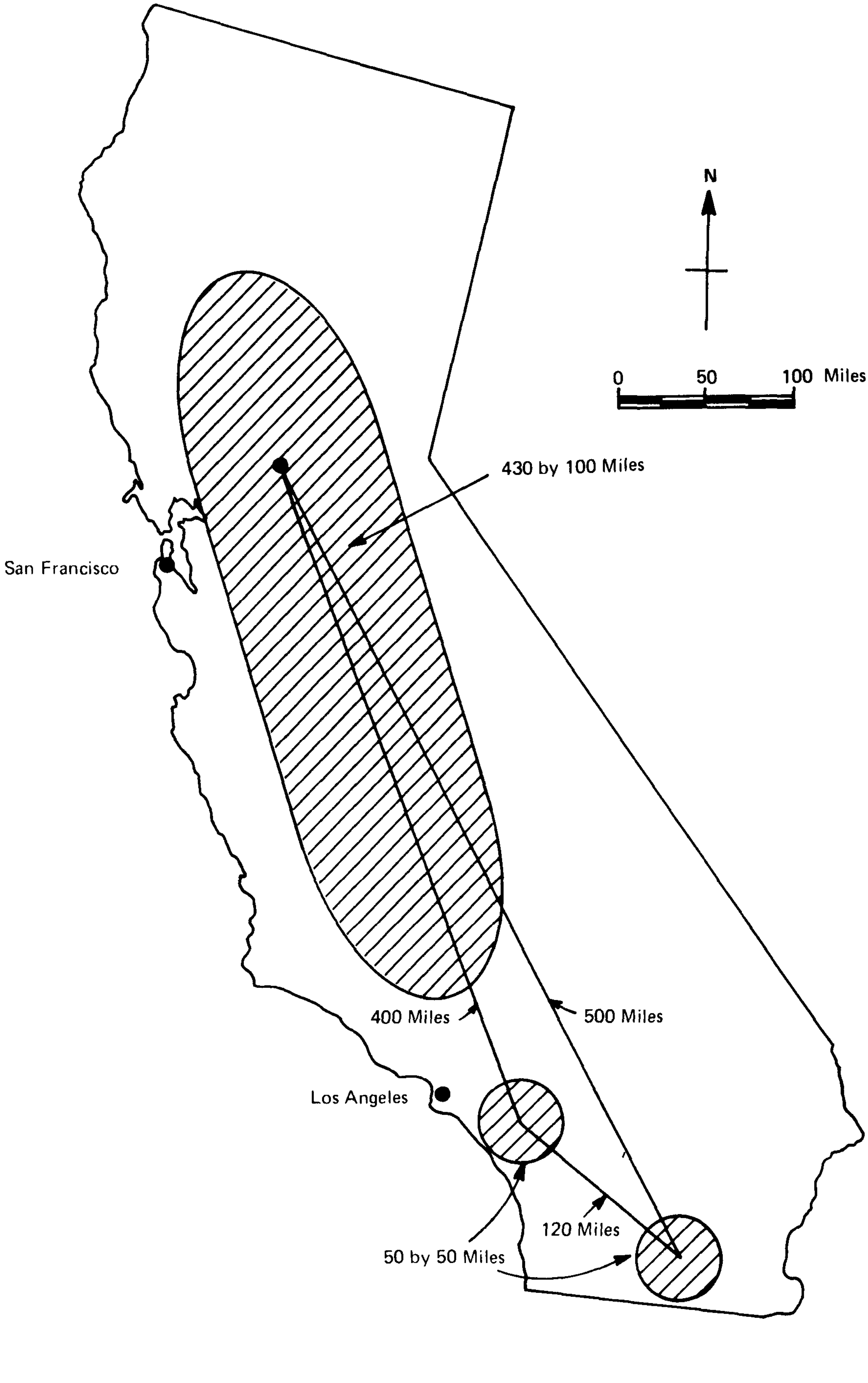


Figure 16. Principal Agricultural Areas in California

C - One incinerator each in the Los Angeles area and in the Imperial Valley
D - One incinerator located in the Imperial Valley serving both the Imperial Valley and the Los Angeles area
E - One incinerator in the San Joaquin Valley serving all three areas.

Table 42 shows the results. At each density, Alternative A is preferable to B for the San Joaquin Valley and D is preferable to C for the Los Angeles-Imperial Valley areas. The cost for a state-wide system combining Alternatives A and D is computed from the costs of each alternative weighed by the number of containers generated in each area. Alternative E is less expensive than the combination of A and D. Therefore, the best incineration system for California is one incinerator in the San Joaquin Valley serving all three agricultural areas.

Similar systems of landfills were also considered. Table 43 shows the results. Two landfills, each serving half of the San Joaquin Valley, are less expensive than one landfill serving the whole area. A combined landfill for the Los Angeles area and Imperial Valley is less expensive (or the same cost at the high density) than separate landfills for each. On a state-wide basis, the best landfill system combines Alternatives B and D with two sites in the San Joaquin Valley and one serving both the Los Angeles area and the Imperial Valley.

For the Alternative landfill systems, the costs do not vary as much from case to case as with the alternative incineration systems.

In Mississippi, the annual generation of containers is somewhat higher than in California, as shown in Table 44.

The area of Mississippi is 47,358 sq miles and agriculture seems to be spread fairly uniformly across the state. The total generation rate is about 9,700,000 lbs/year of all containers (1-gallon and larger are considered); this translates into a density of 204 lb/sq mile-year. If the larger containers (55- and 30-gallon) are reconditioned for reuse, only about 3,100,000 lbs remain for disposal, and the generation density is 65 lb/sq-mile-year.

Assuming a uniform generation density across the state, the only question is how many processing facilities should be located in the state. Using the equations described earlier, the costs of incineration and sanitary landfill were calculated and are shown in Table 45. One incinerator is less expensive than two. For landfills, the best number is around three or four depending on generation density.

Table 42. Cost of Alternative Incinerator Systems in California

a) Density = 36 lb/sq-mile-year

Alternative	Unit Cost (¢/lb)	Statewide System Ave. Unit Cost (¢/lb)
A (one incinerator in San Joaquin Valley)	5.87	
B (two incinerators in San Joaquin Valley)	7.69	7.12 (A and D combined)
C (one incinerator each in Imperial Valley and Los Angeles)	25.27	
D (one incinerator in Imperial Valley)	17.72	
E (one incinerator in San Joaquin Valley serving all areas)		5.75 (E only)

b) Density - 140 lb/sq-mile-year

Alternative	Unit Cost (¢/lb)	Statewide System Ave. Unit Cost (¢/lb)
A (one incinerator in San Joaquin Valley)	3.25	
B (two incinerators in San Joaquin Valley)	3.74	
C (one incinerator each in Imperial Valley and Los Angeles)	11.57	3.76 (A and D combined)
D (one incinerator in Imperial Valley)	8.19	
E (one incinerator in San Joaquin Valley serving all areas)		3.30 (E only)

Table 43. Costs of Alternative Landfill Systems in California

a) Density = 36 lb/sq-mile-year

Alternative	Unit Cost (¢/lb)	Statewide System Ave. Unit Cost (¢/lb)
A - one landfill in San Joaquin Valley	1.70	
B - two landfills in San Joaquin Valley	1.40	1.52 (combination of B and D)
C - one landfill in each of Los Angeles and Imperial Valley	3.02	
D - one combined landfill for Los Angeles and Imperial Valley	2.56	
E - one landfill in San Joaquin Valley serving all areas		1.85 (E only)

b) Density = 140 lb/sq-mile-year

Alternative	Unit Cost (¢/lb)	Statewide System Ave. Unit Cost (¢/lb)
A - one landfill in San Joaquin Valley	1.41	
B - two landfills in San Joaquin Valley	.95	
C - one landfill in each of Los Angeles and Imperial Valley	1.48	1.01 (combination of B and C or B and D)
D - one combined landfill for Los Angeles and Imperial Valley	1.48	
E - one landfill in San Joaquin Valley serving all areas		1.57 (E only)

Table 44. Annual Container Generation in Mississippi (1974)

Size	Number	Estimated Weight (lb)	Total Weight (lb)
55-gal	90,875	60	5,452,500
30-gal	24,050	46	1,106,300
5-gal	334,125	5	1,670,625
1-gal	620,250	2.4	1,488,600
1/2-gal	56,200	1.8	101,160
1/4-gal	124,500	1.3	161,850
	1,250,000		9,981,035

Table 45. Disposal Costs in Mississippi

A) Incineration

Generation Density (lb/sq mi-yr)	Unit Cost of Transport & Disposal (¢/lb)	
	One Incinerator	Two Incinerators
65	4.14	5.20
204	2.64	2.89

B) Landfill

	Unit Cost of Transport & Disposal (¢/lb)			
	1 Landfill	2 Landfills	3 Landfills	4 Landfills
65	1.39	1.06	1.03	1.96
204	1.22	0.79	0.69	0.66

G. CONTAINER DEPOSIT SYSTEM

A deposit system has the potential for providing an economic incentive for the proper disposal of pesticide containers. It is clear that the system will work only if the deposit is high enough. Several possible deposit systems are analyzed in this section in order to establish exactly what "high enough" means, to identify how the costs of implementing a deposit system are distributed among the participants and to uncover any snags which might interfere with implementation.

Two basic deposit systems are considered. In the first, containers go from distributor/dealer to user to a disposal facility. In the second, containers are followed from the formulator to the distributor/dealer to the user and then back through the same chain with the formulator reusing the container.

1. The Distributor/Dealer-User-Disposal System

Figure 17 shows the flow of containers and money in the distributor/dealer-user-disposal system.

The user purchases pesticide from the distributor/dealer and pays a deposit (D). Used containers, less some that are lost, are taken to the disposal facility and the user receives a refund (D) for each container. Deposit revenues collected by the distributor are turned over to the agency which operates the disposal facility, which in turn reimburses the disposal facility. The operating agency must be part of this circuit in order to coordinate the receipt of funds from several distributors/dealers and the possible disbursement of funds to several disposal facilities.

The basis for the economic analysis is taken to be one container going from distributor/dealer to user. If the fraction of the used containers lost by the user is α, the number of containers he delivers to the disposal facility is $(1 - \alpha)$.

The net cost to each participant of handling the containers under the deposit system can be added up. The net cost to the distributor/dealer is:

Income:	D	Deposit received from user
Outgo:	D	Deposit passed on to operating agency
	$+ A_d$	Administrative cost
Net Cost:	A_d	

For the user:

Income:	$(1-\alpha)D$	Deposit refund from disposal facility
Outgo:	D	Deposit paid to distributor/dealer
	$+ (1-\alpha)C_t$	Cost of transporting containers to the disposal facility
	$+ (1-\alpha)F$	Disposal fee paid to the disposal facility.

Net Loss: $\alpha D + (1-\alpha)C_t + (1-\alpha)F$.

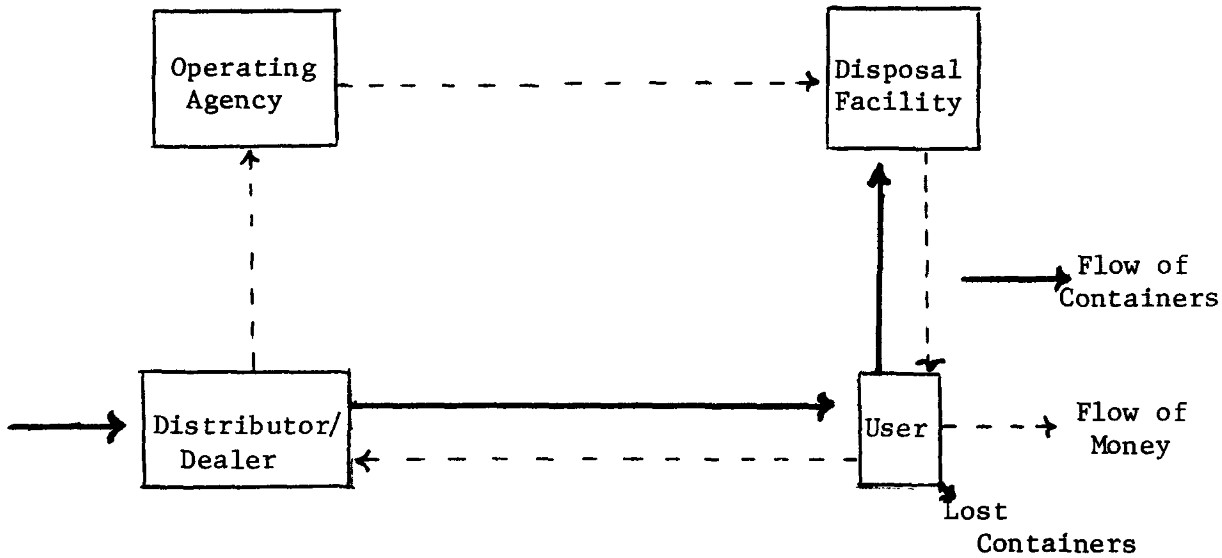


Figure 17. The Distributor-User-Disposal System

The foregoing costs include a disposal fee charged to the user to cover the cost of disposal. Alternatively, that cost would be borne by the operating agency. The user has an economic incentive to deliver the container to the disposal facility if the deposit is greater than the cost to him of the delivery, i.e., if D is greater than $C_t + F_d$.

For the <u>operating agency</u>:

Income:	D	Deposit passed on from the distributor/dealer
Outgo:	$(1-\alpha)D$	Deposit revenue paid to the disposal facility to cover their reimbursement of the user.
	$+A_a$	Administrative cost at agency and disposal facility under its control

Net Cost: $A_a - \alpha D$.

For the <u>disposal facility</u>:

Income:	$(1-\alpha)D$	Deposit revenue from operating agency
	$+ (1-\alpha)F_d$	Disposal fee from the user.
Outgo:	$(1-\alpha)F_d$	Cost of operating the facility.
	$+ (1-\alpha)D$	Deposit paid to the user

Net Cost: nil

The total cost of the system is the sum of the net costs to each of the participants;

A_d	Distributor/dealer administrative cost
$+ A_a$	Operating agencies' administrative cost
$+ (1-\alpha)C_t$	User's delivery cost
$+ (1-\alpha)F_d$	Disposal fee paid by users.

The amount of the deposit does not influence the net cost of the total system. It does, however, affect the transfer of money among the participants, as is shown by the net costs to each. Under the system described, the operating agency gains from a higher deposit and the user loses. The only economic constraint on the amount of the deposit is that it must be larger than the combined cost to the user of delivering the container to the disposal facility and paying the disposal fee.

This system requires recordkeeping by the distributor/dealer, in order that his deposit payments to the operating agency fairly reflect his income from users, and by the disposal facility, in order that it be properly reimbursed from the operating agency for payments made to users. Records must be kept at both levels since payments are made solely on the basis of records rather than on direct delivery of the material as occurs in the user-distributor/dealer and user-disposal facility interactions.

In order to illustrate the transfer of money occasioned by the deposit system, the following values for costs and frational container losses are assumed:

α	= 0.10	The user loses 10 percent of the containers he purchases
A_d	= 1¢	
A_a	= 1¢	
C_t	= 15¢	This cost is quite variable, as was discussed earlier. This value is representative for 5-gallon containers.
F_d	= 15¢	Again, this value is variable, depending on the mode of disposal used.
D	= 40¢	Chosen to be greater than C_t and F_d.

Based on these values, the costs to each of the participants are:

<u>Distributor/Dealer</u> - 1¢

<u>User</u>

(0.1) (40)	lost containers
+(0.90) (15)	transport to facility
+(0.90) (15)	disposal charge
31¢	

<u>Operating Agency</u>

1¢	administrative cost
-(0.10) (40)	gain on deposit transfer
-3¢	the agency makes 3¢ profit.

<u>Disposal Facility</u> - nil

<u>Total Net Cost</u>

1¢	distributor
+31¢	user
- 3¢	operating agency
29¢	this cost includes disposal and transport cost of the containers

In this system the deposit must be greater than 30¢ (the sum of the transport and disposal cost) to provide the desired economic incentive to the user.

The required level of the deposit is changed if the cost of disposal is funded by the operating agency rather than charged directly to the user. Under this condition, the net cost to each participant is:

	General	With Assumed Values
Distributor/Dealer	A_d	1.0¢
User	$\alpha D+(1-\alpha)C_t$	17.5¢
Operating Agency	$A_a+(1-\alpha)F_d-\alpha D$	10.5¢
Disposal Facility	nil	nil
Total Net Cost:	$A_d+A_a+(1-\alpha)C_t+(1-\alpha)F_d$	29.0¢

The total net cost remains the same, with the operating agency bearing the disposal charge rather than the user. Bookkeeping requirements are unchanged. However, the minimum value of the deposit to provide economic incentive to the user drops from C_t plus F_d to C_t (i.e., from 30¢ to 15¢ under the assumed cost values).

Another similar system evolves if the disposal facility is replaced by an independent container reconditioner. The economics are the same as in the first system described, except that the reclaimer may pay the user for the container rather than charging for its disposal.

For this case, the condition on the deposit to provide economic incentive to the user is that D must be greater than C_t-P where P is the price paid by the reclaimer to the user. If P is greater than the delivery cost (C_t), no deposit is required to provide economic incentive.

In providing an economic incentive to the user to return used pesticide containers to the desired place, the deposit system also provides the same incentive to return <u>any</u> container which can pass as a pesticide container. If the pesticide containers are not clearly distinctive, some added operating costs can be expected due to the entrance of extraneous containers into the system at the user level. The number entering will increase with the size of the deposit, and the associated cost will be borne by the disposal facility or the operating agency.

2. The Formulator-Distributor/Dealer-User System

A deposit system in which used containers are passed back to the formulator for reuse is shown in Figure 18. While this system involves carrying the deposit back through the formulator level, the bookkeeping might be simpler than in the system described in the previous section. Here the money flow is always parallel to the flow of containers so that immediate payment can be made on delivery. Detailed records would not be required.

An economic analysis of this system yields essentially the same substantive results as that of the previous system. They are:

- The amount of the deposit does not influence the cost of the system, except as it encourages extraneous containers to enter the system at the user level.

- The amount of the deposit does influence the transfer of payments among the participants. The user loses an amount equal to the deposit for each container that he does not return, and the formulator gains that amount.

- In order to provide an economic incentive to the user, the deposit must exceed the net cost of returning the container to the holding area. This net cost is the sum of the transport cost and the handling fee, if any; or the difference between the transport cost and the price of the user is paid for the container, if any.

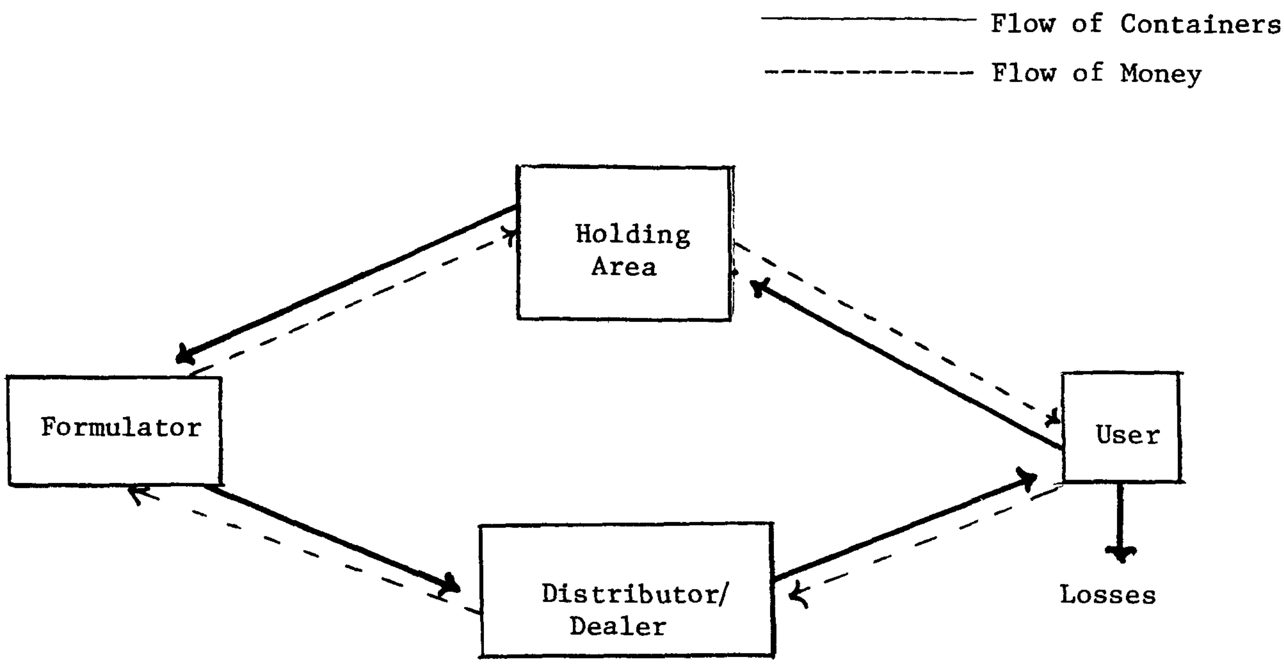


Figure 18. The Formulator-Distributor-User System

VI. ENVIRONMENTAL EFFECTS OF THE DISPOSAL OF PESTICIDE CONTAINERS AND UNUSED PESTICIDES

The discussion of environmental effects is divided into two parts: first, a discussion of the status of the problem as seen from a number of viewpoints including examples of actual environmental effects of the disposal of containers and unused pesticides in various states; second, a discussion of the potential effects of the principal disposal methods, both existing and proposed.

A. INCIDENCE OF ENVIRONMENTAL DAMAGE

The actual amount of damage caused by disposal of containers and unused pesticides is a matter of wide disagreement. One of the reasons for this disagreement is the lack of recordkeeping on the part of states. Although most states keep track of accidents, fishkills and other environmental effects of pesticides in general, often this information is not broken down as to whether the accident was caused by use of the pesticide or by the disposal of the pesticide.

We surveyed briefly the environmental (or agricultural) agencies in 6 states other than those used in field studies for environmental or human accidents related to container and pesticide disposal. Our search yielded reports of very few accidents, posisbly due to the lack of such incidents or the lack of recordkeeping in many states. The results of our survey combined with review of the literature for similar incidents are given below.*

In Maine, reported problems related to disposal of containers have been limited to fishkills, averaging about 2 or 3 per year. The incidence of fishkills is sporatic; in 1974, there were none, and in 1973, there were about 5. Wardens of the Fish and Game Department (authorized to act as enforcers of the regulations) issued 20 to 30 warnings for infractions in 1974.

In Virginia, a container was disposed of near a building with an air vent. The container had only been partially cleaned, and the pesticide material volatilized and was sucked into the vent, poisoning some farm animals inside the building.

In Florida, a citrus grower disposed of bags in a nearby lake, contaminating the water, and causing the death of several aquatic organisms (species or types not immediately available).

*Since many of these incidents were related from memory by state agency personnel, very few details are available. Documentation for these incidents, although existing, was not immediately available.

In Tennessee, a chemical company buried one hundred 55-gallon drums of chlorinated hydrocarbons in shallow, unlined trenches. The pesticides escaped from the containers to contaminate the local ground water supply and a nearby creek (Buder, 1970).

In Minnesota, lead arsenite was found to have contaminated a well, causing a farmer to be taken to the hospital with arsenic poisoning. The lead arsenite had been buried 1000 yards from the well 30 years ago (Trask, 1973).

In Maine, a barn burned down and a pesticide container, with sodium arsenite left in it, was left unsecured. It eventually tipped over and the contents flowed into a low area and mixed with water which cows later drank. Two or three of the cows died.

B. POTENTIAL ENVIRONMENTAL EFFECTS OF DISPOSAL SYSTEMS

The environmental effects of disposing of pesticides and containers depends on the particular hazards of the chemicals involved (toxicity, persistence, solubility, volatility of both the active ingredient and formulation) and the particular susceptibility of the areas in which they are disposed (proximity to surface and ground water systems, human and wildlife accessibility). The wide range of potential severity of environmental effects should be kept in mind when considering the various impacts which could occur.

1. On-Site Disposal

a. Open Dumping of Containers

Open dumping is the most hazardous of all pesticide container disposal methods, and is probably the one that is most commonly used throughout the United States. Open dumping involves discarding containers either in a centralized location on the farm or wherever they happen to be used. Potential environmental hazards of this method of disposal range from sublethal effects to humans to secondary food chain effects. Briefly, the potential environmental hazards include the following:

(1) Humans--The potentially most hazardous aspect of open dumping is the exposure of humans, especially children, to pesticide residues in the container. Since it is likely that persons disposing in this way may also fail to triple rinse the containers, pesticides are normally left in the container. Pesticides could come in contact with umans in the following ways:

- Children could be exposed while playing near discarded pesticide containers,
- Containers could be retrieved from the discarded area and put to use by the farmer's family or other workers.

- Disposing of other pesticide containers, farmers could come in contact with spilled material from previously discarded containers.

Even if such exposure does not result in acute effects such as sickness or death, less noticeable chronic effects may occur especially when the container has been retrieved from an open dump area and put to use on the farm in some way. It is interesting to note that one survey on disposal methods (discussed in Section III) indicates that 10-20% of the containers are "washed and reused."

(2) Farm animals--Farm animals are also susceptible to poisoning from containers which have been discarded around the farm. Rain water may collect around the discarded pesticide containers, and be contaminated by the pesticide residues. Also, water may collect in or on some of the leftover containers themselves. Horses, cows, and other farm animals may drink this water and receive a relatively concentrated dose of the pesticide.

(3) Surface Ground Water Systems--Surface waters may be contaminated when containers are disposed of in surface waters, or near stream banks or other areas which drain into surface waters. Fishkills caused by this contamination are usually very localized and easily traced to the containers nearby. Downward movement, as well as lateral movement, may also be a problem. Percolation of rain water through the soil may lead to leaching of pesticide material into ground water systems. Although not causing the dramatic effects seen with lateral movement into surface water systems, the cumulative contamination of ground water from pesticide containers as well as other pesticide sources may be the more serious of the effects.

(4) Soil--The seepage of pesticide into the soil may also cause a localized effect on the soil ecosystem. Microbial populations are the most dramatically effected of the soil organisms. Pesticides vary widely in their toxicity to various soil microorganisms. Particular chemical structures may be harmful to fungi, while others are only harmful to bacteria and/or actinomycetes. By disposing of several different pesticides in one area, a microorganism which is potentially able to degrade one pesticide might be eliminated by the presence of another pesticide. Also, decreasing the number of species of microorganisms decreases the competition among the numerous types, leading to instability in the soil ecosystem, and possibly leading to the predominance of a relatively few species. Although this in itself is not harmful, the species which become predominant may be harmful to other soil organisms or nearby plants. Plant pathogens may be able to survive applications of pesticides and increase rapidly due to the elimination of competitive species (Edwards, 1973).

A more widespread effect on the soil ecosystem may be caused by the elimination of some benefical soil invertebrates (e.g., earthworms, enchytraeid worms, and some Acarina) which have been shown to be susceptible to pesticides, especially chlorinated hydrocarbons. These organisms are necessary to the soil ecosystem since they contribute to soil fertility by ingesting and breaking down the organic detritus contained in the soil and distributing the nutrients throughout a large area (Edwards, 1973).

(5) Food Chain--The open dumping of pesticide containers can also cause food chain effects. Earthworms and soil mollusks have been shown to accumulate pesticides and may be a hazard to predaceous birds and mammals. Birds and mammals, especially rodents, also directly incorporate the pesticide residues from contact with the disposal area itself or from contaminated water bodies, and pass these residues on to higher trophic levels.

b. "Controlled" On-The-Farm Burial of Pesticide Containers

"Controlled" burial is burial by the farmer in a specified area of the farm by approval or permit of some state or county official. Environmental effects of such a system would depend greatly on the requirements for approval:

- It is likely that surface water contamination would be decreased by this method since inspectors could check for proximity to streams and other water bodies and the possibility of direct lateral movement of leachate to surface waters.

- The amount of ground water contamination which could be controlled by this method would depend on specific site characteristics and the requirements of inspectors. Where the water table is high, controlled burial probably cannot eliminate contamination of ground water by downward movement of the pesticide. If some kind of liner is required, e.g., polyethylene sheeting, this could be controlled to some degree.

The potential for human contact and contact with farm animals would be reduced by this method as compared to open dumping, since at a minimum, the containers would be required to be covered and fenced in. Soil effects would be decreased by use of a liner.

c. Open Burning of Bags

Because of low temperatures (compared to incineration), and variable oxygen supplies, it is likely that the pesticide residues in the bags in an open field will not be completely burned. As such, there will be uncombusted and intermediate compounds given off as vapors. Some of these compounds might include long chain hydrocarbons, phosgenes, and other chlorine compounds, nitrogenous compounds, and others. The particular mixture and quantity of compounds given off is extremely variable because oxygen supply and temperature are not constant throughout the uncontrolled open field burn. For example, on the outside of a container in which bags are burned, there may be sufficient oxygen but the air currents may cool the fire. On the inside, temperature may be high but oxygen may not be sufficient. The end result would be a mixture of vapors representing the various stages of thermal degradation of the pesticide involved. Additionally, vapors of the undecomposed pesticide itself would likely be given off, as well as fumes of hydrochloric acid, sulfuric acid, and other compounds representing a more complete combustion of the pesticide.

The release of these vapors is a potential hazard to people and wildlife downwind of the open field burn. It is likely, however, that the vapors would disperse rapidly enough as to eliminate a hazard to potentially unsuspecting persons or wildlife outside of the immediate area. As a general rule of thumb, it can be estimated that there is a 20-fold dilution in vapors for every 10 'source diameters' away from the burn. This assumes that there is relatively little wind; additional wind velocities would increase dispersion rates. Since some of the vapors mentioned above are toxic at the low ppm range, it is important that the location where bags are burned is chosen so that there will be no known exposure to persons or wildlife for several hundred feet downwind.

Bags containing weed killers, such as 2,4-D, may be burned in the field However, any remaining chemicals volatilize easily and may cause harm to nearby crops, shrubbery, or other plants, it is important to choose the location carefully to minimize adverse effects. Also, those pesticides containing chlorates may be explosive.

Another environmental hazard from burning of bags in the field may result from the unburned pesticide and residues of intermediate compounds being concentrated in the soil directly underneath. The particular mixture and quantity of compounds in the residue would again depend on the completeness of combustion. Care should be taken to burn bags and containers in areas which are not frequented by farm animals, children or wildlife. Any ashes and residues, furthermore, should be spread out or covered with clean soil. It is also advisable to avoid low areas where water might accumulate and result in high concentrations of soluble toxic materials.

The environmental hazard of both vapors in the air and residues in the soil would be decreased if the combustion were more complete. A 'crib' could be constructed of inexpensive material such as available rocks or planks of wood, which would enclose the burn on three sides, allowing an updraft of air and maintaining higher temperatures. Many farmers burn bags in open wire "incinerators."

The above discussion deals primarily with small numbers of bags burned by individual farmers. Burning of large numbers in the field, such as might be done by commercial applicators, should be conducted only in the presence of, or after the approval of, public health officials.

d. Rinsing

Although not a method of disposal, rinsing of pesticide containers deserves attention because of the environmental effects of the disposal of pesticides in the contaminated rinse water. Depending on the quantity of rinse water used, the concentration of pesticides in the rinse water may not be significantly greater than the normal concentrations for application. Small quantities of this rinse water disposed in agricultural fields therefore may not be significantly more harmful than pesticide application.

Commercial applicators, however, may release large amounts of contaminated rinse water into which drains eventually connect to secondary treatment systems. The bacteria in these systems may be exposed to a wide variety of pesticides.

The most likely reaction of most of these bacteria would be to become sluggish and temporarily unable to digest as much organic matter as normal. The cause for this sluggishness may be a decrease in the variety or numbers of the bacteria, or a temporary toxic effect of the pesticide on the individual bacteria themselves. The addition of the relatively small amount of diluted rinse water containing pesticides, however, would not significantly change the overall effectiveness of the treatment facility.

The bacteria, however, probably would not be able to decompose a significant portion of the pesticide unless there were particular strains of bacteria that preferred pesticides as an energy or nutrient source. In general, bacteria would probably prefer nutrients from other wastes which are more easily degraded. It is possible that a strain of bacteria could be added to the secondary treatment system which was known to easily degrade a number of pesticide chemicals.

In areas of heavy pesticide use, it may be necessary to pass the effluent through a carbon filter to avoid contamination of the receiving waters by significant amounts of pesticide compounds. The effect on receiving water bodies will vary considerably with the compounds involved. Chlorinated hydrocarbon insecticides may cause significant harm to populations of lower aquatic organisms whose LC_{50} is often less than .01 ppm. Effluent containing chlorinated hydrocarbon insecticides may also be potentially damaging to fish populations.

2. Intermediate Disposal

The effects of holding areas will probably be minimal if the following three conditions are met:

- The containers are closed and stacked properly so that no pesticides can drain;
- Bags are placed in drums or other closed containers with lids;

- The holding area is enclosed and locked so that children and wildlife cannot reach the containers.

Preferably, the holding area would be on a paved surface to eliminate the possibility of rodents burrowing into the area. The normal precautions should be taken by persons transporting the containers into and out of the holding areas and persons handling the containers within the holding areas to prevent exposure to pesticide residues on the outside of the containers, etc.

3. Final Disposal

a. Effective Sanitary Landfill

The environmental advantage of using a landfill is the fact that the containers are placed away from contact with wildlife or humans. The potential environmental problems include the potential for ground water pollution, surface water pollution, and possible occupational hazards resulting from onsight handling.

The ground and surface water problems can be significantly reduced if thorough investigations of the geology and ground water hydrology of the site are made before the site is designated for disposal of containers (or pesticides). Some of the factors which should be considered are: 1) the hydraulic gradient and the distance between the waste site and any nearby aquifers, 2) the location of the water table, and 3) the sorption characteristics and permeability of the soils beneath the sanitary landfill. Attention should also be given to the amount of rainwater which is allowed to percolate to the sanitary landfill, since a pesticide-contaminated leachate can be produced if percolating water is present in sufficient amount. This leachate could transport the pesticide material downward until it reaches an impervious layer or a zone of saturation, then moving laterally in the general direction of ground water movement. This downward and lateral movement could be significantly lessened if the sites chosen were checked for favorable hydrogeologic conditions prior to the disposal of the pesticide containers (Miller, 1972).

b. Encapsulation of Pesticide Containers

Bags, small metal containers, and other small containers could be placed in 50-gallon drums and buried. The effect is to delay the entrance of the pesticide material in the containers into the soil system until the drums have rusted. This may allow for some chemical decomposition of the pesticides in the containers during this time, but other than that the effects will be the same as simple burial of the containers. More sophisticated encapsulation would involve placing the containers in sealed material such as asphalt. This has been suggested for the disposal of surplus pesticides. Although this would prevent the small amounts of pesticide material in the containers from being released to the soil, the costs may be prohibitive.

c. Incineration of Pesticide Containers

Incineration at temperatures near 1000°C can result in complete incineration of a wide variety of chlorinated hydrocarbons, organophosphates, carbonates, and phenoxy acid herbicides. Because of the reliability and completeness of this degradation, incineration may be the safest method for the disposal of residues in pesticide containers. At high enough temperatures, and with adequate oxygen, most pesticides break down to form SO_2, P_2O_5, HCl, NO_x and other gases which must be eliminated by scrubbing. The only 'secondary' problem involved is assuring the safe disposal of the waste from the gas scrubbing system, and the relatively inert tars and other residues.

d. Reuse/Recycling

Reuse and recycling of pesticide containers involves the collection, cleaning, and use of pesticide containers for other purposes. Hot caustic soda is usually used to clean the containers for their reuse. Although it has been shown that this washing effectively removes the pesticide material from the container, it leaves a toxic effluent which is placed in holding tanks until evaporation has left a dry residue containing a variety of toxic materials. This residue should be disposed in a landfill approved for toxic materials or in incerators. Although some of the pesticide material may have been detoxified in this process, the disposal of this residue may present some of the same environmental hazards as disposal of the pesticide itself.

Reconditioning via an incineration process is more acceptable than washing with caustic soda. As mentioned previously, incineration destroys almost all organic pesticides. This leaves a cleaner, safer container than washing. The environmental effects again arise from disposal of materials which are scrubbed from incinerator stack gases.

C. PESTICIDE DISPOSAL

1. On-Site

a. Open Dumping of Unused Pesticides

Open dumping of unused pesticides involves discarding the surplus pesticide on the farm or in local dumps. (The practice of spreading surplus pesticides over crops according to label directions is also considered a form of open dumping.)

The environmental effects of open dumping of unused pesticides are generally the same as those discussed above under open dumping of pesticide containers, although the hazard to humans is appreciably greater. An added hazard to humans is that small amounts of the surplus pesticides are sometimes removed from the containers for home use. The effects on soil ecosystems, surface and groundwater contamination, and possible food chain hazards are similar to those discussed in regard to containers, but greater in the potential magnitude of impact.

b. Burial of Unused Pesticides on the Farm

This practice is somewhat less dangerous than the open dumping of these pesticides. The hazards to humans are less although groundwater contamination and/or well contamination may result. Soil ecosystem effects will be serious, at least in the localized area of disposal. While wildlife and farm animal exposure may be lessened, food chain effects which originate in the soil ecosystem may be greater.

2. Final Disposition

a. Incineration

The incineration of unused pesticides, if conducted at high enough temperatures, is probably the most environmentally safe method of disposing of unused pesticides. The process and degradation products are virtually the same as those discussed for the incineration of containers. Again, the only 'secondary' disposal problem involved is assuring the safe disposal of the waste from the gas scrubbing system, and the relatively inert tars and other residues.

b. Soil Injection

Soil insection involves placing limited quantities of unused pesticide in the soil allowing it to be degraded by natural biological and chemical processes. Ideally, a soil injection system includes the following components: a high clay content to provide the greatest amount of surface area for adsorption, a continuous supply of organic material with the necessary carbon for bacterial growth and reproduction, a variety of substrates for bacteria and fungi including roots, leaf litter and other organic materials, vents for the release of gases, and possibly some inoculation of bacteria specifically chosen for their ability to degrade pesticides.

One of the drawbacks with this disposal method is its unreliability. It has not been possible to predict the amounts of pesticide which can be degraded by this method. Also, such essential details as how a pesticide effects soil micro-organisms and its amount of mobility in the soil is often not known for individual pesticides.

It may be possible to assure degradation if:

1) Only known non-persistent pesticides are disposed of in this manner,
2) amounts are less than 10 times the normal application rates (or other order of magnitude as determined for different types of pesticide),
3) long durations of time as allowed before additional pesticide is disposed of in the same area, and
4) pesticide movement in the soil is monitored. (Stojanovic, et al, 1972)

Potential impacts of the soil injection methods if environmental safeguards are not met would be the same as those resulting from simple burial of pesticides in soil.

c. Biodegradation

Biodegradation, as a method to degrade unused pesticides, usually refers to microbial degradation. Microbial degradation in the soil has been discussed previously under soil injection. However, microbial degradation can also occur in a liquid medium specifically designed for that purpose. Such a liquid medium would involve a nutrient broth, inoculated with bacteria suited for a wide range of decomposition abilities, and maintained at optimum temperature, aerobic or anaerobic conditions, and pH. Unused pesticides would be added to this medium in quantities which the bacterial culture could decompose without effecting the bacteria themselves. The end products of this system would likely include gases such as methane or other lower hydrocarbons, and sludges of dead bacteria and other waste products.

The techniques in this system would approximate those used in fermentation processes. Lately, the fermentation process has been considered for use in the production of methane from a variety of solid waste materials. The greatest problem which has evolved in attempting to use fermentation for this process has been the unreliability of the bacterial cultures in degrading material. The population dynamics of the bacteria within the broth fluctuate greatly and are sensitive to particular materials added for decomposition. It would seem that this problem would be intensified with the introduction of unused pesticides because of the toxic nature of these compounds. It is possible, however, that bacterial populations could be chosen which used a variety of compounds as energy nutrient sources, and which were not susceptible to the compounds as toxins. More study is needed to determine the potential for this method as a reliable means of disposal of unused pesticides.

The sludge material resulting from this fermentation process would probably be deposited in a sanitary landfill where soil microbes would continue the degradation process. The toxicity of this sludge material to soil microbes (and other organisms which might be exposed to it) would vary considerably because the sludge material itself would be a mixture of undegraded pesticides, partial degradation products and bacteria.

Degradation by contact with isolated microbial enzymes is also a form of biodegradation. Development of this disposal method is still in the experimental stage. However, these experiments (Miller, 1972) demonstrate that particular pesticide-degrading enzymes can be extracted from bacteria and that these enzymes can at least partially degrade some pesticide compounds. Table 46 shows the bacteria which had been used in these enzymes' studies and the corresponding pesticide compounds which they have been shown to degrade. Since this method is still under investigation in the laboratory, very little is known about its possible environmental effects. One potential problem may be the disposal of partially degraded pesticides, since most of the isolated enzymes have not been shown to completely degrade the toxic compounds.

d. Encapsulation

Encapsulation is a method of disposing unused pesticide which involves enclosing the pesticide material within a non-biodegradable substance, such as concrete, and then burying this encapsulated material. Since, in most cases, the concrete enclosure outlines the toxicity of the enclosed pesticide material, the environmental effects of the disposal method would be negligible. Theoretically, 55-gallon drums could also be used for encapsulation of unused pesticides. Since rusting of the containers would release the material in a relatively short time, the environmental effects would be similar to those caused by burial of the material.

e. Chemical Degradation of Unused Pesticides

Chemical degradation is the detoxification of pesticide by reactions with chemical reagents. This method of disposal is in the experimental stage and therefore its environmental effects are difficult to determine. It is likely however that disposal of the waste material may be hazardous, due to the compounds resulting from the chemical reactions, and the presence of partially decomposed pesticides.

Table 46

Bacteria and Pesticide Compounds Tested in Enzyme Degradation Studies

Bacteria from which Enzymes have been Isolated	Pesticides which are Partially Degraded by Isolates
Acthrobacter sp.	2,4-D
Bacillus megaterium	Phosdrin
Geotrichum sp.	DDT DDE (Nearly complete degradation)
Aerobacter aerogenenes	DDT (dechlorinated)
Escherichia coli	DDT (dechlorinated)
Arthrobacter sp.	chlorinated phenols phenoxyacetates
Penicillium sp.	Karsil and related compounds
Bacillus sphaericus	urea herbicides
Microoccus denitrificans	chlorinated aliphatic acids (dehalogenated)

Source: Miller, 1972

VII. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

Based upon the literature survey, the results of field studies, and economic and environmental analysis, we have drawn the following conclusions on the disposal of pesticides and pesticide containers.

Magnitude of the Container and Disposal Problem

The number of pesticide containers and quantities of pesticides which require disposal vary considerably among states or regions depending upon the type and level of agriculture, the pesticide distribution and application systems, availability of disposal facilities, and the degree of attention focused on pesticide disposal. Although the use of larger reusable containers, bulk shipments of pesticides, and closed systems for transfer of pesticides to spray equipment is increasing, the majority of pesticides are sold in 5- to 50-pound bags and cartons and 1- to 5-gallon containers resulting in a large number of containers requiring disposal. The quantity of pesticides requiring disposal is a result of a backlog of outdated, banned or no longer registered, or less effective compounds. This quantity may change depending upon future regulatory actions, pesticide shortages and increasing pesticide costs.

Actual Disposal Practices

The disposal practices used vary considerably in different states and regions and are determined primarily by convenience and economy to the user/disposer and secondarily by existing disposal facilities and regulations. In general, the more visible the problem, the greater the conformance with existing rules or regulations.

Despite the efforts of trade associations, agricultural extension services and state regulatory personnel, triple rinsing of pesticide containers has not been accepted as widely as expected or desired. Regulations promote triple rinsing, but only when they are adequately enforced. Farmers and applicators frequently do not rinse containers or rinse them only once because of lack of time or facilities.

Most paper and cardboard containers of pesticides are burned in the field after they are used. Most small metal, glass and plastic containers are disposed of by on-site open dumping. Burial either on-site or in county dumps or landfills is the second most common practice for small containers. Reuse or recycling of these small metal, glass or plastic containers is almost non-existent. Methods of disposal such as biodegradation, encapsulation, soil degradation, etc., are not widespread. Incineration is used as part of the pesticide container reconditioning process, but is not generally used for container disposal.

There is an increased interest in recycling of small pesticide containers by conversion to scrap and subsequent reuse. There is a trend towards reconditioning and reuse of 30- and 55-gallon containers. Use of plastic containers is increasing; these may be easier to reuse but more difficult to dispose.

Low cost methods for disposal of unwanted, outdated or surplus pesticides are not readily available. The most common practice is to use them as originally intended. When they are disposed, incineration, encapsulation, and burial are the most common practices.

Costs of Disposal

If environmental and social costs are not included, on-site disposal by burial, open dumping and burning are the least costly to the pesticide user. A principal cost of most other systems is the cost of transporting containers to disposal sites. The costs of alternative disposal methods such as landfill, incineration, encapsulation, etc., are strongly dependent upon the scale of operation. The variation of disposal costs with scale of operation, and the variation of transport costs with distance from disposal sites result in an economically optimum system for each disposal method. This optimum depends upon the rate of generation and distribution of containers.

The cost of transport of containers from the user to a central holding area (or disposal site) is high and variable--between 0 and 10¢ per pound. Typical costs for disposal by landfill, encapsulation, incineration, and recycle are between 2-4¢ per pound of container material, e.g., 10-20¢ per 5-gallon container. The costs of regionally developed disposal systems are similar to those of controlled on-site burial if farmer labor costs are taken into account. An economic solution to disposal of large containers is their reconditioning by private contractors provided there are sufficient containers available. The cost of properly operating a returnable deposit system is independent of the amount of deposit; costs are incurred in the transfer of money and associated records keeping by the participants in the disposal system. For a deposit system to be successful, the deposit must be higher than the cost incurred by the user in the return of the container.

Attitudes Towards and Acceptance of Disposal Methods

No single process for disposal of pesticides or pesticide containers is acceptable to all parties that use or distribute pesticides nor is any single process deemed useful for all types and sizes of containers. Processes which are acceptable in one location or state may be totally unacceptable in another. There is little consensus of who should be responsible for pesticide and container disposal, whether disposal systems should be operated privately or by local or state governments, and who should pay for the disposal process. It is generally accepted, however, that the pesticide user plays the key role in any disposal process and most likely will ultimately pay indirectly for disposal.

Most farmers, applicators, dealers, etc., are concerned about the economics and practicality of disposal systems and only secondarily concerned about health and environmental impacts. Most pesticide users believe that disposal of herbicides and herbicide containers are less hazardous than disposal of insecticides and insecticide containers. Dealers and distributors generally believe that disposal is a problem of the pesticide user. They are opposed to any methods which require their storage or handling of used pesticide containers. Farmers and applicators accept the responsibility for disposal but believe that dealers, distributors, and manufacturers should be involved.

Most farmers and applicators prefer on-site disposal methods. All participants in the disposal process believe that open burning of pesticide bags and cardboard containers is acceptable, provided not too many are burned at one time and that practical precautions are undertaken. There is varied opinion on the acceptance of landfill as a disposal method because of the concern over possible concentration of pesticides. Pesticide users and others will cooperate with a recycling and reconditioning system if it is economical and will not increase the costs of pesticides to the user. There is general concurrence that incineration is an acceptable method of pesticide disposal but that its use is costly.

Environmental Effects of Pesticide and Container Disposal

Only recently have most states begun to record incidents of adverse environmental and health effects of improper disposal of pesticides and pesticide containers. Reports to date consist primarily of sporadic and sometimes serious incidents of poisoning of humans and animals, fishkills, and accidents in handling and disposal of containers and pesticides. Chronic problems associated with pesticides and container disposal have not been fully identified.

Open dumping of containers and pesticides is potentially the most hazardous disposal method. Human and animal health hazards are most significant but other possible effects include surface and ground water contamination, wildlife exposure, and soil ecosystem disruption. Incineration is safest from an environmental viewpoint provided sufficiently high temperatures are maintained and scrubbing systems are used. The environmental effects of other disposal methods require additional investigation. Potential problems include unreliability, failure to degrade pesticides completely, and disposal of wastes from these processes.

B. RECOMMENDATIONS

Based upon the results of this investigation, we make the following recommendations:

1. The Environmental Protection Agency should provide to appropriate state agencies basic technical, economic, and environmental data and information on pesticide and pesticide container disposal methods and their effects. Using this information, states should develop enforceable programs and procedures for pesticide and pesticide container disposal which meet guidelines and minimal standards set by the Environmental Protection Agency. The methods and procedures developed by each state must take into account the level and distribution of agriculture and pesticides, available disposal facilities, and user attitudes within the state. Wherever possible pesticide and container disposal should be integrated with regulations and disposal practices for other hazardous wastes generated in the state or region.

2. In setting guidelines and minimum standards for disposal practices, EPA should give careful consideration to all participants in the disposal process, including farmer/user, manufacturer, and the general public. Economics of disposal practices, types of pesticides and containers being disposed, and potential cooperation between pesticide users, persons in the distribution chain, and state agencies should be considered as well as potential environmental and health effects. Special consideration should be given to the small pesticide user, i.e., the individual farmer, since in most states this user is the key element in any disposal process.

3. Pesticide distribution systems which provide economic and environmental advantages by reducing the number of containers for disposal, e.g., bulk tanks, closed systems, large container recycle or reuse, should be encouraged. However, the impacts of these systems on small farmers, applicators and distributors or dealers should be considered prior to their recommendation.

4. In cooperation with state agencies, universities, extension services, and commercial organizations, the Environmental Protection Agency should sponsor a series of pilot research and implementation programs including:

    (a) Development, operation and analysis of several disposal systems, including ones operated by a state or county, and/or holding areas as an intermediary between pesticide user and the final disposal site;

    (b) Implementation of a program to evaluate the costs and impacts of a returnable container deposit system on a state or regional basis;

(c) Development of a program of incentives for commercial pesticide disposal contractors, drum reconditioners, recycle specialists, etc., which would promote a new service sector in the agricultural industry;

(d) Additional programs in states or regions to collect data on the quantity of pesticides and containers for disposal;

(e) Systems analysis of approaches to optimize the location, size, and type of pesticide disposal facilities for specific states or regions; and

(f) Research on the environmental and health hazards and costs of specific pesticide disposal methods--landfills, encapsulation, controlled burial, soil injection, biological and chemical degradation, etc.

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